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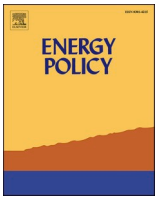

Effects of rescaling the EU energy label on household preferences for top-rated appliances

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ABSTRACT

The European Union has decided to replace its previously existing A+++ to D labelling scheme for cold appliances with a rescaled A to G labelling scheme in 2021. Employing a demographically representative discrete choice experiment on refrigerator adoption using an online survey among more than 1000 households in Germany, this paper explores the effects of the rescaled scheme compared to the previous scheme on the stated uptake of top-rated refrigerators, i.e. those classified A+++ under the previous scheme and B under the rescaled scheme. Since in practice both schemes may be shown for a transitory period, the paper also explores the effects of displaying both labels simultaneously. The findings from estimating a mixed logit model suggest that showing the rescaled label alone significantly increases valuation of top-rated refrigerators compared to showing the previous A+++ to D label alone. In comparison, when the previous A+++ to D and the rescaled A to G schemes are shown simultaneously, no benefits of introducing the rescaled label are found. Thus, policymakers should strive to enforce the application of the rescaled labelling scheme as quickly as possible and to shorten transitory periods where both labels are shown simultaneously.

1. Introduction

To enable customers to make informed product choices based on their energy use, many countries have introduced energy labelling schemes as a key policy to achieve energy and climate policy targets. Similarly to other eco-labels, energy labels are expected to induce consumers to purchase more environmentally-friendly products through the provision of observable, uniform, and credible information (e.g. Truffer et al., 2001; Liu et al., 2016). For the European Union (EU), the 'Labelling Directive' (European Economic Community, 1992) has mandated manufacturers and retail stores the use of comparative energy labels for household appliances since 1995. The initial labelling schemes included seven energy efficiency classes visualized by horizontal bars of different lengths and colors, ranging from the green class-A label for the appliances with the best energy performance to the red class-G label for appliances with the worst energy performance. To account for technological progress in energy efficiency, the EU subsequently introduced additional classes A+, A++ and A+++ in 2004 for some appliances, including refrigerating appliances (European Commission, 2003; European Union, 2010) and in 2011 eventually removed the lowest classes E to G from the label for these appliances to maintain seven energy efficiency classes on the label. As a result, for these appliances, from 2011 onwards, the three efficiency classes A+, A++ and A+++ were separately depicted with different shades of green on the label, while Class A labels received a yellow color code. Further, a tightening of minimum energy performance standards (MEPS) in 2010 (e.g. European Commission, 2009) led to refrigerating appliances with an energy efficiency class lower than A+ no longer being allowed to be sold in the EU market after 2014. Therefore, since 2014, all refrigerators and freezers on the market have had a green color code; however, the label still includes energy classes that no longer meet the MEPS requirements (Classes A to D).

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This updated A+++ to D EU energy labelling scheme of 2011 (in combination with a tightening of the MEPS in 2010) is generally believed to have increased the market share of top-rated appliances, i.e. appliances belonging to the highest energy class (e.g. Bertoldi et al., 2016; Bjerregaard and Møller, 2019; Schleich et al., 2021).[1] However, the scaling policy may have reduced the effectiveness of the label, because consumers may have erroneously interpreted an A+ label as a top energy efficiency rating (Heinzle and Wüstenhagen, 2012). In response to these concerns, the European Union (European Union, 2017) decided to reintroduce the initial classification using only the letters A to G. This new labelling scale also involves rescaling of appliances so that an appliance classified A+++ (A++, A+ respectively) could for instance be reclassified B (E, G, respectively). Because the rescaling is based on a new calculation method, an appliance classified A+++ may be classified B, C, or even D under the rescaled label; the Class A will intentionally be kept empty in the initial phases of introduction of the rescaled label, implying that top-rated appliances will be rated B in the early phases of the rescaling process.

For cold appliances (such as refrigerators, freezers, wine storage units, and minibars), household washing machines and washer-dryers, household dishwashers, and electronic displays (such as televisions, monitors and digital signage displays), dealers are asked to replace the A+++ to D label with the rescaled A to G label within a period of two weeks starting March 1, 2021. Derogations to this requirement exist and, if applicable, appliances can be sold with the old label until November 30, 2021. In addition, an initial transition period during which dealers could start preparing the transition and where both labels could be included in the appliance packaging already applied from November 1, 2020 onwards (European Union, 2019). In practice, during these transition periods, appliances labelled with the A+++ to D and with the rescaled A to G label are simultaneously available on the market. On September 1, 2021, rescaled labels will also apply to light sources such as lamps (with an 18-month transition period until February 28, 2023). Other product groups, for which progress in energy efficiency has been relatively slow (i.e. no or few products currently qualify for the highest label classes) such as air conditioners and space and water heaters are scheduled to gradually receive the rescaled label by 2030.

In this paper we analyze the effects of the rescaled A to G labelling scheme on household preferences for top-rated refrigerators compared to the A+++ to D scheme. We further explore the effects of simultaneously using both labels on preferences, since it is unclear whether such simultaneous labelling would serve to help consumers make a decision, or unintentionally confuse them. To do so, we employ an online stated preferences discrete choice experiment (DCE) on refrigerator adoption using a demographically representative sample of 1099 households in Germany, the most populous country in the EU.

Several studies have previously relied on stated preferences experiments through online surveys to study hypothetical adoption of household appliances, typically finding participants to respond positively (i.e. purchase more efficient appliances) to the information provided on energy labels, or to certification by an energy label. For the US Energy Guide labels, these studies include Davis and Metcalf (2016) for air conditioners, Newell and Siikamäki (2014) for water heaters, and Ward et al. (2011) and Liu et al. (2016) for refrigerators. For labels in China, similar results were obtained by Shen and Saijo (2009) for air conditioners and refrigerators, by Zha et al. (2020) for refrigerators and washing machines, and by Zhou and Bukenya (2016) for air conditioners, and in Malaysia for refrigerator-freezers by Saidur et al. (2005). In addition, a few studies have analyzed moderating factors of the EU label effectiveness. For Germany, Andor et al. (2019) find participants with low cognitive ability to be particularly responsive to the energy label. Also for Germany, Andor et al. (2020) conclude that adding information about annual energy costs (in addition to kWh displayed) to the EU energy label increases the uptake of energy-efficient refrigerators. Relying on identical surveys in eight EU countries, Guetlein et al. (2019) find participants with high energy literacy to more strongly value appliances with a top energy label. Finally, employing a field experiment in Italy, d'Adda et al. (2021) conclude that consumers make almost optimal appliance choices based on the coarse information signals provided by the labels' letter grades.

Our study is closest to Heinzle and Wüstenhagen (2012), who find, for samples of 90 and 97 persons by treatment groups, that - prior to its actual implementation - adding the categories A+, A++, and A+++ to the existing A to G labelling scheme in 2011 lowered the importance of energy efficiency in the hypothetical adoption of TVs by households in Germany. Note that this finding may have been partially driven by participants' lack of familiarity with the (at the time new) A+++ to D labelling scheme. Confounding effects due to lack of familiarity should not be an issue with our study since consumers will likely be familiar with the rescaled label (identical to the label used before 2011 and to labels used for other product categories such as ovens, tumble dryers or air conditioners). Further, in contrast to Heinzle and Wüstenhagen (2012), our study on refrigerators uses larger samples of about 400 persons per treatment group. Finally, our study is the first to explicitly test the effects of a simultaneous usage of old and rescaled labels.

We organize the remainder of the paper as follows. Section 2 describes the methodology including the survey, the DCEs for the various labelling schemes, and the econometric model. Section 3 presents the results. Finally, the concluding Section 4 discusses the findings and possible policy implications.

2. Methodology

2.1. Survey

We tested the effects of introducing the rescaled label through an online survey conducted in July and August 2018 in Germany as part of a larger study on household preferences for energy-efficient technologies and policies. The survey was conducted in cooperation with a market research company, NORSTAT, who contacted members of their online household panel for participation in the survey; respondents received a participation fee from NORSTAT for completing the survey. Participants were selected via quota sampling to be representative of the German adult population (between 18 and 65 years of age) on the criteria of gender, income, regional population distribution, and age. After some initial screening questions on the quota criteria and before answering questions on individual and household characteristics, respondents were randomly assigned to participate in two successive DCEs on different technologies or policies.

Out of 1178 panel members who participated in the DCE on labelling schemes described in detail in section 2.2, 1099 (93%) completed the entire questionnaire. Incomplete responses were excluded from the analysis. The median time that respondents took to complete the survey including both DCEs was 19 min. Table A1 in the Appendix presents the descriptive statistics for our sample and treatment groups together with the descriptive statistics. As we will detail in section 2.2., the treatment groups differed depending on whether they saw the old A+++ to D label, the rescaled A to G label, or both labels simultaneously. There are slightly fewer women than men in the second group compared to the other two groups. The difference is significant (Pearson's chi-squared test; $p = 0.091$). We therefore test whether gender has an effect on results presented in Section 3 but do not find any significant gender effects. Otherwise, no notable differences are observed across groups.

[1] See Schleich et al. (2021) for a recent historic account of EU legislation for cold appliances, i.e. the EU labelling scheme and MEPS. According to Bertoldi et al. (2016), average energy consumption of a new cooling appliance sold in the EU decreased by 12.4 percent between 2010 and 2014. Controlling for the counterfactual development, Schleich et al. (2021) analyze the combined effects of changes in the MEPS and the energy labels entering into force in the EU in 2010 and 2011. Their findings for the period of 2007–2017 suggest that these policies increased the market share of cold appliances with an energy label of A+ and better between about 15 and 38 percentage points in the eight EU countries in their sample.

Table 1
Levels of different attributes considered in the refrigerator choice experiments.

Attribute	Levels
Size	220 L, 240 L, 260 L, 280 L, 300 L, 320 L
Energy class	Group *'A+++ to D label'*: A^{+}, A^{++}, A^{+++}/Group *'rescaled label'*: G, E, B/Group *'both labels'*: A^{+}/G, A^{++}/E, A^{+++}/B
Warranty	2 years; 4 years; 6 years
Customer rating	3.5/5 stars; 4.0/5 stars; 4.5/5 stars
Purchase price	€250, €350, €450, €550, €700, €850

2.2. Discrete choice experiments

The following framing was used to introduce the choice experiment (see also Appendix Figure A1):

> *"In this part of the survey, we invite you to make a series of hypothetical* ***choices between different refrigerators.*** *There are no right or wrong answers to these questions.*
> *Imagine that* ***your refrigerator has broken down and you need to buy a new one.*** *On the following pages, we will show you different refrigerator purchase options. We would like to know* ***which refrigerator you would choose, if these were your only options.*** *Please assume that all refrigerator options fit properly in your kitchen and are currently available in color and finish of your choice. "*[2]

This framing, adapted from Ward et al. (2011) and Li et al. (2016), was chosen to mitigate hypothetical bias since participants are told that they have to project themselves in a situation where their existing refrigerator had broken down (a realistic possibility that justifies choosing a new system).

Following the framing, participants read a detailed description of the attributes on which these refrigerators differed: size, energy class, warranty, customer ratings, and purchase price (see Table 1 for the attributes and attribute levels and Figure A2 in the Appendix for an example of a choice card shown to participants). The levels for refrigerator size and price were chosen to represent the variety of refrigerator size and price options available on the market in Germany at the time of the study. We did not include extreme options such as mini-refrigerators or luxury price refrigerators to ensure that the options proposed were realistic and could be seriously considered by the majority of consumers. Based on previous literature using DCEs on refrigerators and on information available on websites selling refrigerators, we also included warranty and customer ratings as attributes that are relevant for refrigerator purchase decisions, and that are independent from the other attributes included. Length of warranty was chosen to vary from 2 to 6 years. Customer ratings have been shown to have a great impact on purchase decisions (Chevalier and Mayzlin, 2006; Moe and Trusov, 2011); in our DCE, they were described through the typical five-star representation used in many online stores, with three possible levels, ranging from 3.5 stars to 4.5 stars.

To explore the effects of different labelling schemes, we randomly assigned participants to three separate groups differing by the type of energy label shown: (1) A+++ to D label (specifically, choosing between refrigerators labelled A+++, A++ or A+),[3] (2) rescaled A to G label (choosing between refrigerators labelled B, E, or G), or (3) simultaneous use of both labels (i.e. choosing between refrigerators labelled A+ under the A+++ to D label and G under the rescaled one, or A++ and E, or A+++ and B). In the first two groups, participants were told that "Refrigerators come with a label that looks like the following", which was then followed by a stylized picture of the label shown (see Fig. 1 for the pictures). For the third group, participants were told that "Refrigerators come with two labels, the current label, and a new label that is replacing the current label", and were shown both labels named as "current label" and "new label". For all respondents, the picture of the label(s) was followed by a sentence explaining that "The color **"green"** indicates a lower energy consumption while the color **"red"** indicates a higher energy consumption compared to refrigerators with the same volume and features."[4] Finally, participants were informed that they would choose among refrigerators with energy class A+++, A++, or A+ (for groups 1 and 3) or B, E, and G (Group 2). Participants in Group 3 also were informed that the energy classes A+++, A++, or A+ correspond to classes B, E, and G according to the new label (all energy classes were bolded in text). The equivalence from one label system to the next was established based upon information provided on the European Commission website about the rescaled label and to represent the range of energy classes that will be available on the market upon introduction of the rescaled label.

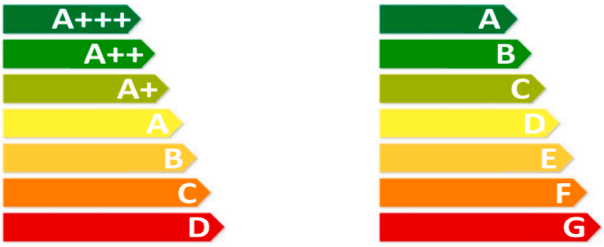

Fig. 1. Stylized pictures of the labels as shown to participants.

The equivalence from one labelling scheme to the next is not obvious and depends on various product characteristics. In particular, the Energy Efficiency Index (EEI) based on which energy classes are determined is calculated differently under the A+++ to D and the rescaled labelling schemes (see Commission Delegated Regulation (EU) 1060/2010 and Commission Delegated Regulation (EU) 2019/2016). Thus, appliances with the same energy efficiency class under the previous labelling scheme might be labelled differently under the rescaled labelling scheme. At the same time, requirements for the rescaled label are such that the most efficient appliances as of 2020 will be rated B at best (i.e. class A will remain empty at first). The least efficient appliances available on the market in 2020 – including some A+-labelled appliances – will fall into the lowest category, G. As a consequence, we decided to translate all A+++ appliances into B appliances, A++ into E, and A+ into G.

Participants were then asked to respond to six scenarios, each consisting of a choice between two refrigerator purchase options. Because respondents were forced to choose a refrigerator among the alternatives proposed (to replace a broken one), this DCE did not include the status quo option of keeping the current refrigerator). The scenarios were obtained through the application of a Bayesian efficient design (Sándor and Wedel, 2001) using the NGENE software (ChoiceMetrics, 2014). Bayesian efficient designs assume orthogonal attributes and are used to reduce the large number of possible attribute level combinations to an efficient design taking into consideration uncertainty about prior parameters. In this study, the prior distributions were based on a separate pretest conducted in the UK with 50 respondents.[5]

2.3. Econometric model

We use a mixed logit model to analyze the data from the DCE. Unlike conditional logit models, mixed logit models allow coefficients to vary across individuals and do not rely on the Independence from Irrelevant Alternatives (IIA) assumption (Revelt and Train, 1998). In a panel setting where n denotes individuals, t choice situations and j choice

[2] Instructions in 'bold ' were also seen in 'bold' by participants.

[3] Following a tightening of the MEPS (European Commission, 2009), only cold appliances labelled A+ or better were allowed to be sold on the EU market.

[4] The expressions "**"green"** indicates a lower energy consumption" were color-coded in green and "**"red"** indicates a higher energy consumption" color-coded in red in the survey.

[5] The pretest was conducted as part of a larger pretest of the entire survey, which was part of a larger multi-country project. For budgetary reasons, all pretests were conducted in the UK before translation in the various languages.

alternatives, the utility function can be expressed as

$$U_{njt} = \beta_n^{'} X_{njt} + \varepsilon_{njt},\ n = 1, \ldots, N \quad j = 1, \ldots, \mathrm{J} \quad t = 1, \ldots, T \tag{1}$$

X_{njt} is a vector of attributes of the alternative and β_n a vector of random parameters that varies across participants. β_n can be characterized by a density function $f(\beta_n|\theta)$ with a vector of parameters θ (Train, 2003). Finally, ε_{njt} denotes the error term. Our DCE consists of 12 choice situations divided into two blocks and with two choice alternatives each, hence T = 12 and J = 2.

Assuming that ε_{njt} is distributed iid extreme value, the probability to observe that participant n chooses a sequence of alternatives $s = (j_1, j_2, \ldots, j_T)$ is given by

$$S_n(\theta) = \int \prod_{t=1}^{T} \frac{\exp(\beta'_n X_{nit})}{\sum_{j=1}^{J} \exp(\beta'_n X_{njt})} f(\beta_n|\theta) d\beta_n \tag{2}$$

The log likelihood function can be written as:

$$LL(\theta) = \sum_{n=1}^{N} \ln \mathrm{S}_n(\theta) \tag{3}$$

Equation (2) cannot be solved analytically. Instead, the probability is approximated through simulations. Let $P_n(\beta_n) = \prod_{t=1}^{T} \frac{\exp(\beta'_n X_{nit})}{\sum_{j=1}^{J} \exp(\beta'_n X_{njt})}$ denote the conditional probability that participant n chooses a sequence of alternatives for a known β_n. We obtain the simulated log likelihood by running a simulation with R Halton draws (Train, 2003):

$$SLL(\theta) = \sum_{n=1}^{N} \ln \left\{ \frac{1}{R} \sum_{1}^{R} \mathrm{P}_n(\beta_n^{\ r}) \right\} \tag{4}$$

where β^r is the rth draw from $f(\beta_n|\theta)$. We used $R = 250$.

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

$$\widehat{WTP}_x = -\frac{\widehat{\beta}_x}{\widehat{\beta}_p} \tag{5}$$

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

To allow testing for differences in labelling schemes, we use the observations from all three groups and include interaction terms reflecting the various labelling schemes for the label attributes.[6] The utility function may then be written as:

$$\begin{aligned} U_{njt} = {} & \beta_1 price + \beta_{n,2} size + \beta_{n,3} A2 + (\beta_4 rescaled + \beta_5 both) \times A2 + \beta_{n,6} A3 \\ & + (\beta_7 rescaled + \beta_8 both) \times A3 + \beta_{n,9} warranty + \beta_{n,10} star4 + \beta_{n,11} star45 \\ & + \varepsilon_{njt} \end{aligned} \tag{6}$$

A2 and A3 are dummy variables indicating an alternative with the second highest energy class (i.e. A++ or E) and the highest energy class (i.e. A+++ or B), respectively. Thus, we use the lowest energy class A1 (i.e. A+ or G) as a baseline (see Table 2). Similarly, a rating of 3.5 is used as the baseline for the customer rating scheme. *Rescaled* and *both* are dummy variables indicating whether participants saw only the rescaled energy labelling scheme or saw both energy labelling schemes simultaneously. For participants who only saw the A+++ to D label, *rescaled* and *both* are equal to zero. The parameter of the price attribute and all interaction terms in equation (6) are specified as fixed parameters. All other parameters are modelled as random parameters and are assumed to be normally distributed as is standard in the literature.

[6] We note that estimating three models separately would not produce correct standard errors to test for differences in the effectiveness of the label schemes.

3. Results

3.1. Results of mixed logit model

We present the results of the mixed logit model in Table 3. The upper part reports the means of the parameter estimates while the lower part shows their standard deviations. Half the standard deviations of the parameter estimates are statistically significant, implying heterogeneity of these parameters across respondents and supporting the use of a mixed logit model rather than a conditional logit model. We report the point estimates for the marginal willingness to pay in Table 4 using equation (5).

Before discussing the findings for the different labelling schemes, we first turn to the results for the other attributes. As expected, the parameter estimate associated with *price* is negative and statistically significant. A higher purchasing price lowers respondents' willingness to select a particular refrigerator. The mean of the parameter estimate of *size* is statistically significant and positive, implying that on average respondents prefer larger refrigerators to smaller ones. Table 4 suggests that respondents are willing to pay 0.62 Euros for an additional liter in volume. Similarly, respondents prefer refrigerators with longer warranties; on average, they are willing to pay about 30 Euros for an additional year of warranty. Next, the findings for the coefficients associated with *star4* and *star45* imply that respondents value refrigerators with higher customer ratings compared to a 3-star baseline rating. More specifically, on average respondents are willing to pay an additional 42 and 114 Euros for a 4-star-rated and 4.5 star-rated refrigerator compared to a 3.5-star rated refrigerator, respectively.[7]

Turning next to the parameters for energy class, we find the coefficients associated with A2 and A3 to be positive and statistically significant. Thus, for the A+++ to D energy class label, respondents value refrigerators with better energy classes than A+. In particular, they are willing to pay about 116 Euros more for a refrigerator labelled as A++ and about 331 Euros more for a refrigerator labelled as A+++ than for a refrigerator labelled as A+. The findings for the interaction terms suggest that under the rescaled label, respondents value top-rated refrigerators more than under the A+++ to D label or than when both labels are shown simultaneously, with a difference in WTP amounting to about 233 Euros. There appears to be no difference between valuations of the highest energy class for respondents seeing the A+++ to D label or both A+++ to D and rescaled A to G labels simultaneously.[8]

Moreover, we find no evidence that the rescaled label or showing both labels has any effect on participants' valuation of refrigerators with the second highest energy class.[9] Therefore, Table 4 reports the same

[7] Because we found women to be slightly underrepresented among respondents who saw the rescaled label, we estimated a mixed logit model with additional interaction terms between gender, energy classes and labelling schemes. We found no evidence that gender had an effect on the valuation of higher energy classes in any of the treatment groups.

[8] Re-estimating the model in equation (6) with A2 as baseline rather than A1 yields almost identical results: compared to an A2-labelled refrigerator, the WTP for an A3-labelled refrigerator is €232 under the old A+++ to D label or when both labels are shown simultaneously, and €448 under the rescaled A to G label. Results from the estimation with A2 as baseline are available from the authors upon request.

[9] Re-estimating the model in equation (6) with the rescaled label as baseline confirms that showing both labels simultaneously instead of only the rescaled label has no effect on the valuation of the second highest energy class (A++ under the A+++ to D label scheme). Results from the model with the rescaled label as baseline are shown in Table A2 in the Appendix.

Table 2
Coding of energy efficiency classes across treatment groups.

Variable name	Corresponding label displayed in group 'A+++ to D label'	Corresponding label displayed in group 'rescaled label'	Corresponding label displayed in group 'both labels'
A1 (baseline)	A+	G	A+ and G
A2	A++	E	A++ and E
A3	A+++	B	A+++ and B

marginal willingness to pay for A2 for all groups.[10,11] The difference in valuation of the highest energy class under the A+++ to D label (or when both labels are shown simultaneously) and under the rescaled label has direct implications on expected market shares of the different energy classes. Using post-estimation analysis, we calculate the share of respondents expected to purchase A1, A2, and A3 refrigerators (corresponding to A+, A++ and A+++ for the A+++ to D label and to G, E, B for the rescaled label) under different scenarios. For this estimation, we use prices of €344, €518, and €694 for A1-, A2-, and A3-labelled refrigerators,[12] but keep all other attribute levels identical across energy classes. Under the A+++ to D label (or when both labels are shown simultaneously), we estimate market shares of 37% for A3, 31% for A2, and 32% for the A1 refrigerators. Showing only the rescaled label would result in an increase in the market share of A3 refrigerators by 16 percentage points to 53%, whereas the market shares of less efficient refrigerators would decline to 22% for A1 and 26% for A2 refrigerators.

3.2. Robustness checks

To assess the robustness of our findings we carried out two types of additional analyses. First, because participants are not in an actual purchase situation, our findings may suffer from hypothetical bias. In our DCE, respondents were told to imagine that their refrigerator had broken down and needed to be replaced. However, respondents who were actually considering replacing their refrigerator might react differently to the options presented to them in the choice experiment. In particular, we would expect hypothetical bias to be lower for these respondents since they are 'in the market'. To examine whether this is the case, we ran the model in Table 3 only for the subsample of respondents who stated that they were planning to replace their refrigerator within the next three years (25% of the overall sample). Results from this estimation are qualitatively (i.e. in terms of direction and significance of parameters) and quantitatively (i.e. in terms of willingness-to-pay values) very similar to the results presented in Tables 3 and 4. We therefore find that our results are robust even when only including respondents who are 'in the market'.[13]

Second, we tested the sensitivity of our findings when the sample no longer included speeders, i.e. participants who took less than two-thirds the median response time to complete the survey because those might not have taken the DCE tasks seriously. While excluding these 'speeders' resulted in a loss of 207 participants (i.e. about 19% of observations), the findings for this smaller sample are very similar to those presented in Tables 3 and 4. Thus, our findings do not appear to be affected by keeping 'speeders' in the sample.

4. Conclusion and policy implications

The European Union has decided to replace its A+++ to D labelling scheme for cold appliances by a rescaled A to G labelling scheme in all member states in March 2021, with transitory periods before the official implementation (from November 2020 to February 2021) and after this implementation for some special cases (until end of November 2021), leading to the possibility that consumers may see both labels simultaneously. Employing a demographically representative DCE on refrigerator adoption using an online survey among households in Germany, we explored the effects of the rescaled scheme compared to the previous scheme on the stated uptake of top-rated refrigerators. We also analyzed the effects of showing both labelling schemes simultaneously.

4.1. Main findings

Our findings from estimating a mixed logit model suggest that overall, households prefer better classified refrigerators to worse classified ones. In addition, when the rescaled labels are shown alone, the rescaled A to G labelling scheme significantly increases the estimated WTP for top-rated refrigerators compared to the previous scheme. In contrast, when the A+++ to D scheme and the rescaled A to G scheme are shown simultaneously, no benefits of introducing the rescaled label are found. Moreover, we find no evidence that showing the rescaled label instead of the A+++ to D label has an effect on the valuation of the second-best energy class (A++ under the A+++ to D labelling scheme).

There are a few explanations for these results. First, and this was the main criticism of the introduction of the A+ to A+++ classes (see Heinzle and Wüstenhagen, 2012), our findings show that participants perceive the difference between B and G (or E) under the rescaled scheme to be larger than the difference between A+++ and A+ under the old scheme. The rescaling makes it apparent that appliances graded A+ are the worst on the market (a reality that was hidden under the A+++ to D labelling scheme).

Second, the rescaled label also implies that the differences between appliances are more pronounced on the scale. Even appliances with the best energy performance are only rated B, whereas the lowest-rated appliances are rated G. Therefore, whereas under the previous label there were only two classes difference between an A+++ and an A+ appliance, under the rescaled label, there are five classes difference between the best and the worst performing appliances. Third and relatedly, as a consequence of this broadening of the scale, only top-rated appliances are in the green zone (instead of all of them being in the green zone under the A+++ to D label),

[10] To explore whether socio-economic characteristics help explain the higher valuation of top rated (A3) appliances under the rescaled label scheme than under the G to A+++ label scheme, we also estimated a series of additional models for the pooled sample. In these models, we included interaction terms between the label dummies and dummies reflecting socio-economic characteristics (gender, age, income, and education). Only one of the additional interaction terms turned out to be statistically significant. We find that moving from the A+++ to D label to the rescaled label increases the valuation of the top rated refrigerators more for respondents who have at least a high school diploma than for respondents with lower levels of education ($p < 0.1$). Thus, in general, socio-economic characteristics do not appear to explain differences in valuations across the label schemes. Full results are available from the authors upon request.

[11] We tested whether participants attach a higher importance to the energy label under the rescaled scheme than under the A+++ to D scheme. To this end, we used responses to a question asking participants to indicate how much they considered each of the attributes when making their choices in the DCE scenarios. Response options ranged from 1 (not at all) to 5 (very strongly). Based on t-tests, we find no evidence for a difference in the extent to which respondents considered the energy labels between the three groups (i.e. those who saw the A+++ to D label only, those who saw the rescaled label only, and those who saw both labels simultaneously).

[12] These prices correspond to average market prices for 330 L refrigerators of the respective energy label classes in Germany in 2017. This data was acquired from the Gesellschaft für Konsumforschung (GfK).

[13] Full results for both robustness checks are available from the authors upon request.

Table 3
Results for mixed logit model.[†]

	Pooled sample
Means of parameter estimates	
price	−0.005***
	(0.000)
size	0.003***
	(0.000)
warranty	0.142***
	(0.000)
star4	0.202***
	(0.000)
star45	0.543***
	(0.000)
A2	0.557***
	(0.000)
A3	1.580***
	(0.000)
A2_rescaled	0.170
	(0.311)
A3_rescaled	1.114***
	(0.000)
A2_both	−0.061
	(0.713)
A3_both	−0.002
	(0.992)
Standard deviations of parameter estimates	
size	0.000
	(0.919)
warranty	0.030
	(0.760)
star4	0.023
	(0.805)
star45	1.175***
	(0.000)
A2	1.503***
	(0.000)
A3	2.000***
	(0.000)
Log likelihood	−3770.468
Number of participants	1099
Number of observations	13188

* $p < 0.10$.** $p < 0.05$.*** $p < 0.01$.† p-values are shown in parentheses.

with appliances formerly classified A++ moving to the yellow zone and appliances formerly classified A+ to the red zone. Previous research has shown the impact of labels' color coding and especially of so-called traffic light color-coding on consumer decisions (e.g. Thøgersen and Nielsen, 2016; Tourangeau et al., 2007). This new color classification might also explain why only top-rated appliances benefit from the rescaled label. Thus, under the rescaled labelling scheme, participants appear to value energy ratings more than under the previous A+++ to D labelling scheme. Possibly, the rescaled label changes the cognitive mapping undertaken by consumers leading to higher weights for top-rated appliances in the latent utility function.

Our results are consistent with those from Heinzle and Wüstenhagen (2012) who had found that the introduction of the A+++ to D label might lead to confusion and have detrimental effects on the adoption of top rated appliances. Similarly, our results suggest that the adoption of top-rated appliances is higher under the A to G label than under the A+++ to D label. Because the rescaled label is already familiar to EU consumers, it is unlikely that effects are due to lack of familiarity with either of the labels. Besides, if familiarity played a role, it would in this case play against the A to G label. As a consequence, our approach enables a more conservative test of the effectiveness of the A to G label compared to the A+++ to D label. Finally, we find that the simultaneous use of the A+++ to D label and the rescaled label eliminates the beneficial effects of introducing the rescaled label, possibly because the inconsistent information is dismissed.

Table 4
Marginal willingness to pay estimates.[a]

		A++ to D label	Rescaled label	Both labels
size	0.62			
warranty	29.72			
star4	42.24			
star45	113.55			
A2		116.46	116.46	116.46
A3		330.63	563.64	330.63
Number of participants		367	365	367

[a] Only the significant parameter estimates from Table 3 were used in calculating WTP estimates.

4.2. Limitations

Hypothetical bias is a common concern for DCEs (e.g. Hensher et al., 2010) because study participants are not in an actual purchase situation. This bias is particularly affecting the WTP estimates which are often inflated. Unfortunately, it was not practicable within this study to incentivize decisions (i.e. inform respondents that they might have to actually purchase the refrigerator chosen). Instead, we used a so called 'cheap talk' framing (e.g. Ward et al., 2011 or Li et al., 2016) that first reassures respondents about the fact that there are no right or wrong answers and most importantly frames the decision as a necessary replacement of a broken appliance. This is a realistic scenario in which respondents can easily project themselves, and that helps increase the realism of the task. Furthermore, we found that the results were robust even when the analysis only focused on the subsample of participants who were planning to actually replace their refrigerators that is, on those who were 'in the market'. Finally, our focus in this study was not on the absolute WTP levels for various energy classes but rather on comparisons between these valuations across label scheme treatment groups. As a consequence, hypothetical bias should be less of a concern than it is when the focus in on WTP levels.

4.3. Implications for policy makers

Last but not least, our findings have clear policy implications. First, they suggest that the introduction of the rescaled A to G scheme will indeed increase the take-up of top-rated appliances and make the less efficient appliances on the market considerably less attractive. This is of course important because it speaks for the effectiveness of the A to G label and the appropriateness of returning to this label in the EU. Second, results on the simultaneous use of the A+++ to D and the rescaled labelling schemes indicate the necessity to reduce transition periods during which both labels may appear simultaneously to a minimum. This recommendation also applies for the next steps in the implementation of the EU energy label regulations. First, as mentioned in the introduction, the first label rescaling in March 2021 concerns multiple product categories (cold appliances, washing machines, electronic displays); label rescaling is already planned for further product categories (lighting sources in September 2021, air conditioning and other appliances until 2030). We expect our results to be relevant for these rescaling efforts, independent of the product category concerned. Further, the regulation anticipates a regular scaling update (probably every 10 years) of the label classes (European Union, 2017) within the A to G labelling scheme to account for technological progress and for the fact that over time, more and more appliances will be developed for the top energy classes. A regular scaling update is therefore anticipated, implying that top appliances would at best be classified Class B and all other appliances would be rescaled in lower classes. Our results should also apply to these future rescaling efforts and also suggest the necessity to keep transition periods to a minimum, which is consistent with the recommendations made in the regulation (European Union, 2017).

CRediT authorship contribution statement

Corinne Faure: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Marie-Charlotte Guetlein:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Joachim Schleich:** Conceptualization, Methodology, Investigation, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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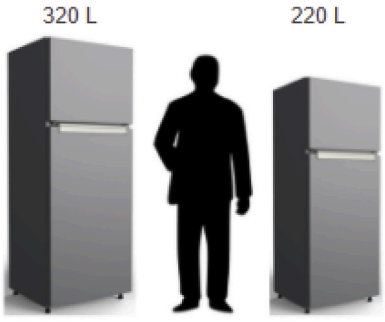
Appendix

Introduction

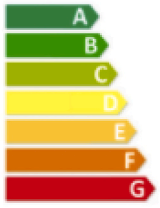
Imagine that **your refrigerator has broken down and you need to buy a new one.** On the following pages, we will show you different refrigerator purchase options. We would like to know **which refrigerator you would choose, if these were your only options.**
Please assume that all refrigerator options fit properly in your kitchen and are currently available in colour and finish of your choice.

The refrigerators only differ on the following attributes:

1. Size: The total **internal space** of each refrigerator is 220, 240, 260, 280, 300, or 320 litres. 20 litres corresponds to one small compartment. The picture below shows a 320-litre and a 220-litre refrigerator.



2. Energy class: Refrigerators come with a label that looks like the following :



The colour **"green"** indicates a lower energy consumption while the colour **"red"** indicates a higher energy consumption compared to refrigerators with the same volume and features.
You will choose among refrigerators with energy class **B, E, or G**.

3. Warranty: The **warranty** for each refrigerator is 2, 4, or 6 years.

4. Customer rating: Ratings are provided by customers who have bought the same refrigerator. You may assume that the refrigerators you can choose from have **average ratings** of 2.5, 3.5, or 4.5 stars out of 5 stars.

5. Purchase price: Each **refrigerator costs 250€, 350€, 450€, 550€, 700€, or 850€**.

Fig. A1. Framing of discrete choice experiment on refrigerators.[†,†] Displayed in German to participants.

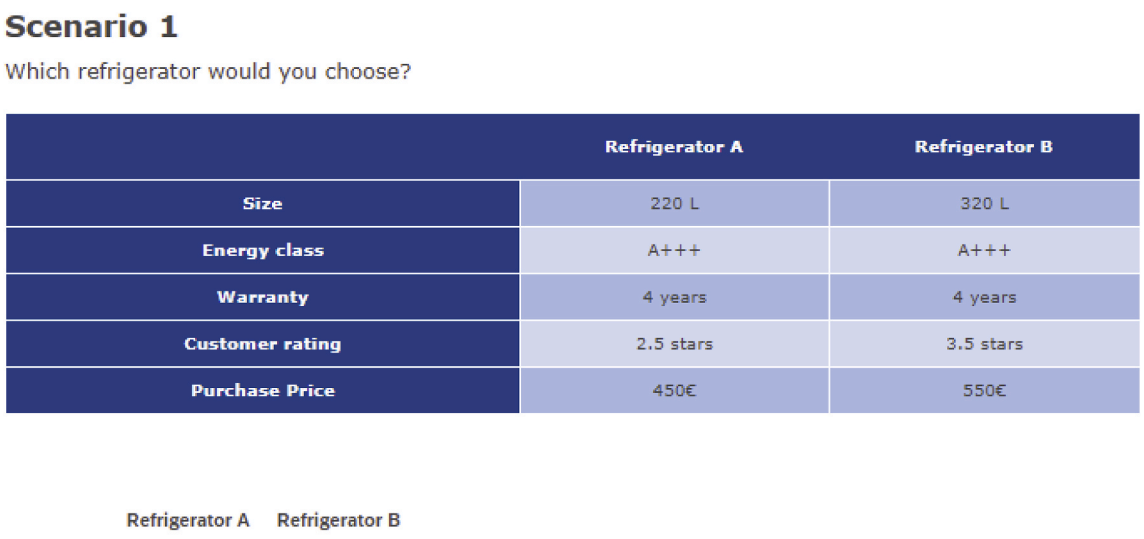


Fig. A2. Example of a scenario shown to participants in the refrigerator choice experiment. [†,†] Displayed in German to participants.

Table A1
Descriptive statistics.

Variable	Sample size	A+++ to D label	Rescaled label	Both labels	National census
Median age[†]	45	44	45	45	46
Female (18–65)	51%	53%	46%	53%	49%
States of former East Germany	15%	14%	15%	17%	15%
Median net household income (in €)[††]	29,300	29,300	29,300	29,300	22,647
Number of participants	1099	367	365	367	

Source: Eurostat.
[†]The national median age is the median age of the entire population, based on census data.
[††]The median net household income is calculated using the midpoints of a scale with 12 income categories. The national median net household income is the median equivalized net household income of the entire population in 2018.

Table A2
Results for the mixed logit model with rescaled label as baseline.[†]

	Pooled sample
Means of parameter estimates	
price	−0.005***
	(0.000)
size	0.003***
	(0.000)
warranty	0.145***
	(0.000)
star4	0.200***
	(0.000)
star45	0.563***
	(0.000)
A2	0.724***
	(0.000)
A3	2.736***
	(0.000)
A2_old_label	−0.166
	(0.329)
A3_old_label	−1.135***
	(0.000)
A2_both	−0.221
	(0.190)
A3_both	−1.141***

(*continued on next page*)

Table A2 (*continued*)

	Pooled sample
	(0.000)
Standard deviations of parameter estimates	
size	0.000
	(0.797)
warranty	0.063
	(0.275)
star4	0.024
	(0.810)
star45	1.192***
	(0.000)
A2	1.523***
	(0.000)
A3	2.016***
	(0.000)
Log likelihood	−3768.491
Number of participants	1099
Number of observations	13188

*$p < 0.10$.
**$p < 0.05$.
***$p < 0.01$.
†p-values are shown in parentheses.

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