CONSumer Energy Efficiency Decision making

REPORT ON CHOICE EXPERIMENTS ON THE EFFECTIVENESS OF PROVIDING INFORMATION ON ENERGY COSTS ON ENERGY RELATED DECISIONS IN HOUSEHOLDS

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Executive Summary

We conducted three discrete choice experiments (DCEs) on consumer choices within transport (cars), property (houses/apartments), and household appliances (refrigerators) in Norway, Slovenia, and Greece, respectively. All three DCEs use a split sample approach to estimate the effect of providing monetary information, in addition to the mandatory (physical) energy use labels, on the willingness to pay for the energy efficiency (EE) attribute. The transport and property DCEs are to some extent comparable, and both show a statistically significant increase in the willingness to pay when monetary estimates are included (as compared with the control group). It is more problematic to compare the results from the household appliance DCE with the other two, as this DCE uses a nested split-sample design (first level labelled versus non-labelled, second level physical energy use versus monetary energy cost). For the household appliance DCE, the willingness to pay decreases for the monetary cost information treatments (as compared with the physical energy use treatments/control). This decrease is, however, not statistically significant.

We also explore the impact of gender on the willingness to pay. In all three DCEs we find that women have a higher willingness to pay, but with mixed results regarding how the treatment influences the willingness to pay (highest increase for men in the Norwegian DCE, for women in the Slovenian DCE, and with non-significant results in the Greek DCE). The finding that women have a higher willingness to pay for energy efficiency is consistent with previous findings in the literature, including findings in the 11 surveys conducted as part of CONSEED (see previous Deliverable 3.1).

The findings from the three DCEs indicate that consumers' willingness to pay for more energy efficient cars and properties can be increased by providing monetary energy information, rather than the current approach of providing information on physical energy use. From a policy perspective, this increased willingness to pay could have desirable knock-on effects such as increased premiums for cars and properties with lower energy use, which would in turn incentivise car manufacturers and property builders and owners to invest more in energy efficiency improvements.

The results for refrigerators indicate a (statistically insignificant) decrease in the willingness to pay for energy savings when labels accompany energy information with monetary estimates. Hence, we cannot recommend the inclusion of monetary information for refrigerators based on our DCE.

1 Terms of reference

The objective of CONSEED Work Package 4 is to obtain experimental data (stated and revealed preferences) on the effectiveness of providing information on energy costs for energy related decisions for households, specifically to:

- Conduct field trials in the three markets with mandatory energy efficiency information requirements (household appliances, properties and cars) to analyse whether providing explicit information about energy costs can induce more consumers to make energy efficient decisions.
- Conduct choice experiments (DCEs) to explore whether the importance assigned to energy use in purchasing decisions varies across different labelling schemes. We will focus particularly on the effectiveness of explicit information about energy costs. Separate but coordinated experiments will be conducted for housing, appliances, and cars.
- Provide an overall assessment of the potential effectiveness of providing households with information about energy costs.

This deliverable concerns the second of the three bullet points. A separate deliverable (Deliverable 4.1) reports on the results from the field trials.

Based on previous research by the CONSEED project team and others (for example, Kallbekken, 2013; Carroll *et al*, 2016, Tigchelaar et al. 2011), we hypothesize that household consumers do not fully make use of the existing EU energy efficiency labels displayed on appliances, cars and properties in their decisions. The aim of the DCEs in CONSEED is to test whether displaying monetary usage labels would further encourage household consumers to purchase more efficient appliances, properties and cars compared with their purchasing behavior with the current EU labels. We do so through three DCEs focusing on purchases of:

- Properties in Slovenia (DCE leader: UL)
- New cars in Norway (DCE leader: CICERO)
- Household appliances in Greece (DCE leader: AUA)

The design of the three DCEs was informed by the results from the focus group studies (previous Deliverable 2.1. from CONSEED).

1.1 Methods

For all three DCEs undertaken as part of CONSEED Work Package 4 we employed a split sample approach, where we split the overall sample of respondents between control and treatment group(s). While the attributes and attribute levels remained consistent across the control and treatment groups for the respective experiments, we altered how the energy consumption information was provided, specifically to provide monetary estimates, either in addition to or in the place of conventional energy consumption information.

The three DCEs address three different products in three different countries, and comparability is therefore limited. All, however, focus on the impact of providing monetary cost information, and the

impacts of the treatments on the willingness to pay for more energy efficient products are therefore to some extent comparable.

The basic conditional logit (CL) model is employed for all studies below. This choice model builds upon Random Utility Model (RUM) (Luce 1959; McFadden 1973) and states that the utility of alternative j for individual i can be decomposed into a deterministic part (V, a linear combination of alternative attributes) and a stochastic element (ε) which represents unobservable influences on the respondent's choice:

$$U_{ij} = V_{ij}(X_{ij}) + \varepsilon_{ij} = \sum_{m=1}^{M} \beta_m X_{mj} + \beta_P P_j + \varepsilon_{ij}$$

where X are a set of attributes, P is price, and β are coefficients (marginal utilities of attributes). The individual will choose the alternative with the highest utility.

For the models below, we randomly assign different energy labels to control and treatment groups and explore changes in the utility of energy efficiency. The general specification therefore extends to:

$$U_{ij} = \sum_{m=1}^{M} \beta_m X_{mj} + \beta_P P_j + \beta_E E_j + \beta_T T_i + \beta_{ET}(E_j * T_i) + \varepsilon_{ij}$$

where E is energy efficiency and T is treatment. The interaction coefficient β_{ET} shows how the utility of energy efficiency improvements increase/decrease for the treatment group.

The marginal willingness-to-pay (WTP) for an attribute equals the marginal rate of substitution between the attribute and price. For example, the WTP for energy efficiency in the control group is simply the energy efficiency coefficient divided by the price coefficient:

$$WTP_E = -\frac{\beta_E}{\beta_P}$$

For the treatment group, we add the interaction coefficient to the numerator:

$$WTP_E = -\frac{(\beta_E + \beta_{ET})}{\beta_P}$$

To test that our policy conclusions are robust to alternative specifications we also analyse the Norwegian and Slovenian data using a mixed logit model.

2 Findings

The next three sections report on the findings from the three DCEs individually. All sections follow the same structure: We explain and justify the choice of attributes and levels; explain the DCE design; provide details of the implementation; show the results from the conditional logit analyses of the impact on willingness to pay for energy efficiency of the treatment (s); show how gender impacts on the results; and finally we discuss policy implications for the specific case.

2.1 Transport DCE in Norway

The purpose of the DCE in Norway is to estimate the willingness to pay for more fuel efficient (new) cars, and how this willingness is influenced by how energy information is displayed. The study relies on a split-sample design to test the impact of additional information on estimated cost of energy use per month alongside the mandatory EU label on physical energy use (litres per 100 km).

Attributes and levels

Based on the focus groups with Norwegian car buyers (see Deliverable 2.1 from CONSEED) we identified price, safety, size and fuel consumption as four of the most important attributes when deciding on which new car to buy. Other attributes, such as fuel type or brand were not highlighted in the focus groups and have not been included in the study. For each of the selected attributes we identified reasonable levels based on information obtained from various online sources. As there is considerable variation in the car market, not least across brands, we chose the family segments (compact, estate and MPV) for the best-selling car brand in Norway, which is Volkswagen (with the models are Golf, Passat, and Touran), and used this as a mental model to help ensure a credible combination of the attribute levels.

- For *price* we have four levels (NOK 350,000, 400,000, 450,000 and 500,000) which correspond to the actual range for the three Volkswagen cars, except the most expensive Passat models.
- The *fuel consumption* of the petrol engine cars ranges from 4.8 to 7.3 litres per 100 km, which we extended somewhat to cover five levels in equal steps (4, 5, 6, 7 and 8). This extended range overlaps very well with the averages for the five most efficient and least efficient compact and family cars in Norway.
- We used *boot capacity* as a proxy for size, and the three models have a boot capacity of 380, 650 and 742 litres for the Golf, Passat and Touran models, respectively. We represented this by four levels increasing in equal steps (400, 500, 600 and 700 levels).
- For *safety* there was limited variation between the models, as all score very high on the Euro NCAP test. We therefore had to abandon the mental model in this case, and instead chose among the full range of car models available. The approximate average rating for the worst, median and best cars tested in 2015 was 71, 80 and 89 points (out of 100), which we represented as three equidistant levels (70, 80 and 90).

Table 2.1.1. Attributes and levels for the transport DCE

Price (NOK)	Fuel consumption (Litre/100 km)	Size (litres boot capacity	Safety (% of max Euro NCAP result)
350,000	4	400	70
400,000	5	500	80
450,000	6	600	90
500,000	7	700	
	8		

Design

The experiment was designed using a split sample approach, where half the respondents undertook the control version of the experiment, and half the respondents undertook the treatment version. The information provided in the treatment version differs from the control version only with respect to the estimated monthly cost (see Figures 2.1.1 and 2.1.2 below). The experimental design was carried out using JMP software package, based upon the selected attributes and predetermined priors.[1] The results of the design process yielded 32 choice sets which were split into four blocks of eight to avoid respondent fatigue. These blocks were then replicated for both the control and treatment versions of the experiment. From the perspective of a given respondent, once they began the experiment they were allocated to either a control or treatment block, where they were asked to undertake eight choice scenarios.

Implementation

This experiment was distributed as part of wider survey undertaken in November 2017 exploring the role of energy efficiency in new car purchases among Norwegian consumers. The survey was distributed by the survey company Opinion among members of the respondent database panel.no. The target group was the adult Norwegian population who have at some point purchased a new car, or were planning to do so within the next 12 months. The survey received 1,093 completed responses. The response rate was 30%., 50.8% of respondents were male, and 94.8% currently have access to a car in their household.

Figure 2.1.1 below shows an example of how we combined attributes and levels to create choice pairs in the treatment group, and Figure 2.1.2 shows an example of the equivalent choice pair from the control group. The translation of the text can be found in Appendix A.

[1] https://www.jmp.com/support/help/14/example-of-a-choice-design.shtml

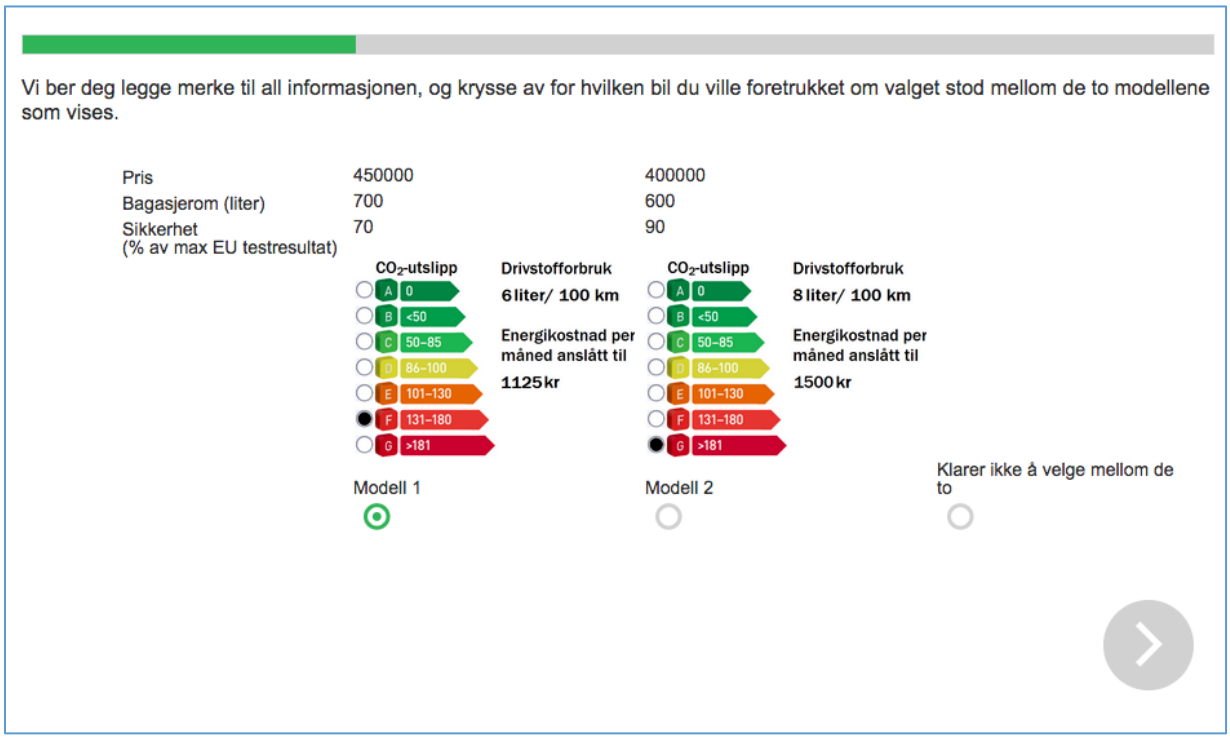

Figure 2.1.1 Screenshot showing a choice pair from the treatment group in the transport DCE

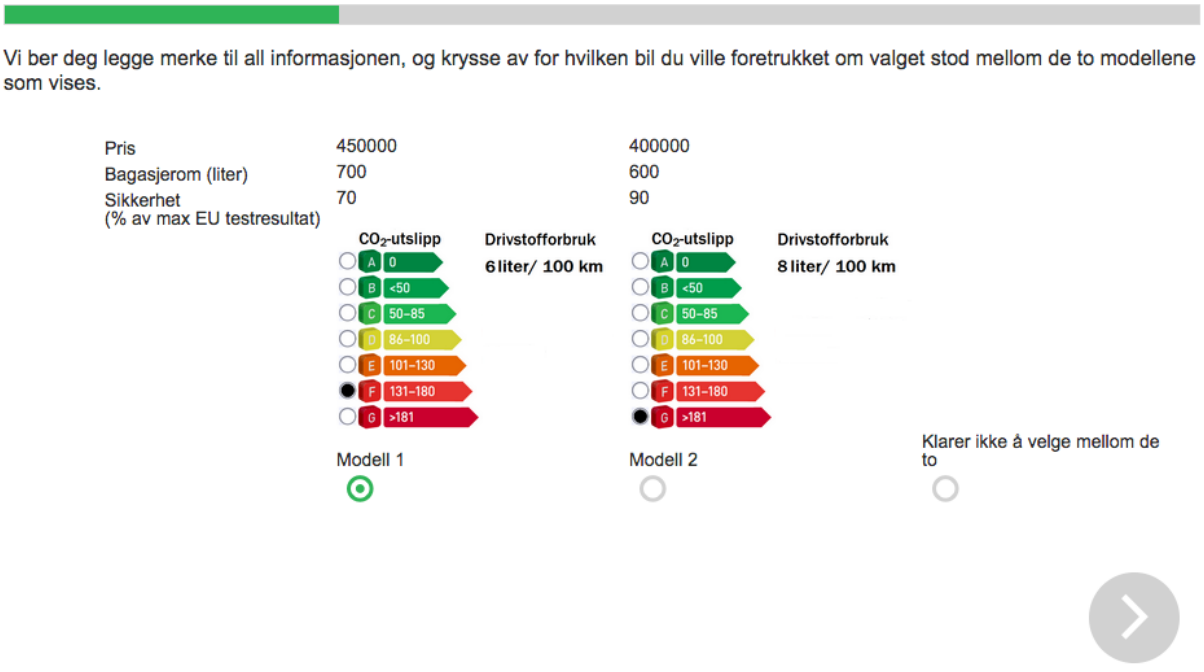

Figure 2.1.2 Screenshot showing a choice pair from the control group in the transport DCE

Results

Table 2.1.2 presents the characteristics of the respective control and treatment samples with regard to their age, gender, and stated levels of environmental concern (calculated from a Likert statement where 1 = not concerned and 4 = extremely concerned). These results show that there two samples can be considered to be very similar in composition, and that the levels of stated environmental concern did not vary significantly (two-sided t-test p=0.458 for age, Pearson Chi-Square p=0.694 for gender and p=0.805 for environmental concern).

Table 2.1.2 Key characteristics of control and treatment samples from the transport DCE

	Control	Treatment
Respondents	555	538
Mean age (years)	48.40	49.16
Female share	49.37%	50.56%
Mean environmental concern (1-4)	2.52	2.58

The results of the conditional logit model based upon the Norwegian discrete choice experiment are presented in Table 2.1.3. The cost and fuel consumption variables have been modelled as continuous variables, whereas the capacity and safety variables are dummy coded, with the lowest level (least safe and smallest capacity) taken as the reference variables. These results indicate that all the variables included were highly statistically significant. In addition, the sign of parameters is as expected, with increases in cost and fuel consumption leading to decreases in utility, while increases in both safety and capacity are linked with increased levels of utility. The interaction variable (treatment x fuel consumption) also emerged as being highly statistically significant, indicating that the inclusion of monetary information in the treatment label had a detectable effect on consumer choices.

Table 2.1.3 Conditional logit results from the transport DCE

	Value	Stand Err	Z
Cost	-0.572D-05***	.332D-06	-17.22
Fuel Consumption	-0.494***	.0183	-27.08
Treatment	0.724***	.166	4.37
Interaction (treatment dummy x fuel consumption)	-0.0940***	.0248	-3.79
Capacity L2 (level 500l)	0.326***	.0397	8.21
Capacity L3 (level 600l)	0.596***	.0418	14.27
Capacity L4 (level 700l)	0.594***	.0511	11.63
Safety L2 (level 80%)	0.313***	.0347	9.04
Safety L3 (level 90%)	0.672***	.0440	15.26
Constant	-6.150***	.193	-31.79

Table 2.1.4 outlines the willingness to pay values for the both the control and treatment groups within the sample. The results show an estimate of 86,374 NOK for a one level decrease in fuel consumption for the control group, and a 102,795 NOK decrease for the treatment group. This represents a 19% increase in willingness to pay when fuel consumption information is provided with monetary information, with respect to the treatment approach. The estimated numbers are large, likely in some part due to the high salience of the energy information. Such over-valuation of energy efficiency is not uncommon, and has been reported in previous studies Andor, Gerster et al. (2017). We do not consider this a critical drawback, as the purpose of our study is not to provide precise point estimates of the willingness to pay, but rather to test the relative differences arising from the monetary cost treatment.

Table 2.1.4 Willingness to pay estimates from the control and treatment groups in the transport DCE

MNL Model	WTP (NOK)	Stand Err	Z	Confidence Interval
Control	86,374***	5,470	15.79	75,652 to 97,095
Treatment	102,795***	6,335	16.23	90,378 to 115,211

Impact of Gender

The role of gender has previously been highlighted as important in energy efficient investments. With regards to the Norwegian study, Table 2.1.5 outlines the results of an analysis of the differences in

respective willingness to pay values arising from the conditional logit model, based upon the gender split within the sample. These results demonstrate that, for both the control and treatment samples, there is a significant difference between the valuations of energy efficiency observed, with females demonstrating a higher valuation for EE than males. However, the effects of treatment are considerably stronger for males (control/treatment difference significant at 1% level) than for females (only significant at the 10% level).

Table 2.1.5 Willingness to pay estimates from the control and treatment groups in the transport DCE

	WTP (NOK)	Stand Err	Z	Confidence Interval
Male Sample:				
Control	74,330***	6,270	-11.85	62,040 to 86,620
Treatment	94,117***	7,596	-12.39	79,230 to 109,004
Female Sample:				
Control	101,691***	9,848	-10.33	82,390 to 120,992
Treatment	113,428***	10,818	-10.49	92,225 to 134,630

Policy implications

The results arising from this experiment indicate a clear increase in the willingness to pay for energy savings, in this case reduced fuel consumption, when labels accompany energy information with monetary estimates. This indicates that including monetary running/energy cost estimates in energy labels may be a useful strategy for increasing the uptake of more fuel-efficient cars. While the DCE focused on internal combustion engines, the reductions in energy costs are larger for hybrids and electric cars, and might therefore prove even more effective in promoting such vehicles.

2.2 Property DCE in Slovenia

The purpose of the DCE in Slovenia is to estimate the willingness to pay for more fuel-efficient homes, and how this willingness is influenced by how energy information is displayed. The study relies on a split-sample design to test the impact of additional information on estimated cost of energy use per month alongside the mandatory EU Energy Performance Certificates.

Attributes and levels

Based on a focus group study with Slovenian home buyers (see Deliverable 2.1 from CONSEED), a number of attributes were identified, in addition to energy and cost, for inclusion in the choice experiment. These were the energy rating of the dwelling, the price, the condition of the dwelling, its distance to the city centre, and its location. As the survey was undertaken across Slovenia, where property prices vary considerably from one region to another, the price attribute was represented as a percentage of the average price within the respondent's given region. Moreover, results from the CONSEED consumer survey (see Deliverable 3.1 from CONSEED) showed that 80% of Slovenian households are already aware of the energy label.

Table 2.2.1 outlines the attributes and levels included in the Slovenian choice experiment. Seven levels of energy efficiency were selected (from A to G), while four levels of condition (represented as the age of the property since its last adaptation), three location attributes, five relative price attributes, and three attributes regarding distance from important infrastructure, such as bus, post office, school kindergarten.

Table 2.2.1 Attributes and levels for the property DCE

Energy Efficiency	Condition (last adaptation of the property)	Location	Price (% of Average)	Distance
A	Brand New	City Centre	80%	1
B	5 years ago	Suburbs	90%	2
C	10 years ago	Outside City	100%	3
D	20 years ago		110%	
E			120%	
F				
G				

As the survey was conducted nationwide, it was not possible to present a representative price attribute to survey respondents. Instead, property prices were displayed in terms of percentage differences. For the

final analysis, we combined this percentage difference attribute with average property prices in the respondent's region (11 regions) to create a continuous price variable.

Design

The design of the Slovenia DCE employed a split sample approach, like the Norwegian experiment, where respondents were shown either the control or the treatment labels. Half of the respondents were shown an existing energy label (control group) and the other half received the new energy label with information provided in monetary units (treatment group). Unlike the experimental design undertaken in the Norwegian DCE, pre-determined choice sets and blocks were not employed, instead using the Sawtooth software package and a balanced overlap design, an individual specific set of choice scenarios was generated for a given respondent based upon the selected attributes and levels.

Implementation

The experiment was distributed as part of wider survey undertaken in November 2017 exploring the role of energy efficiency in household investments in the Slovenian property sector. The survey was distributed by the Slovenian firm Aragon d.o.o.

Figure 2.2.1 outlines a sample scenario from the Slovenian DCE displayed in the control format. In this scenario, the energy consumption information (*Poraba energije*) is provided in the form of kilowatt hours per metre squared, in addition to the letter and colour coding.

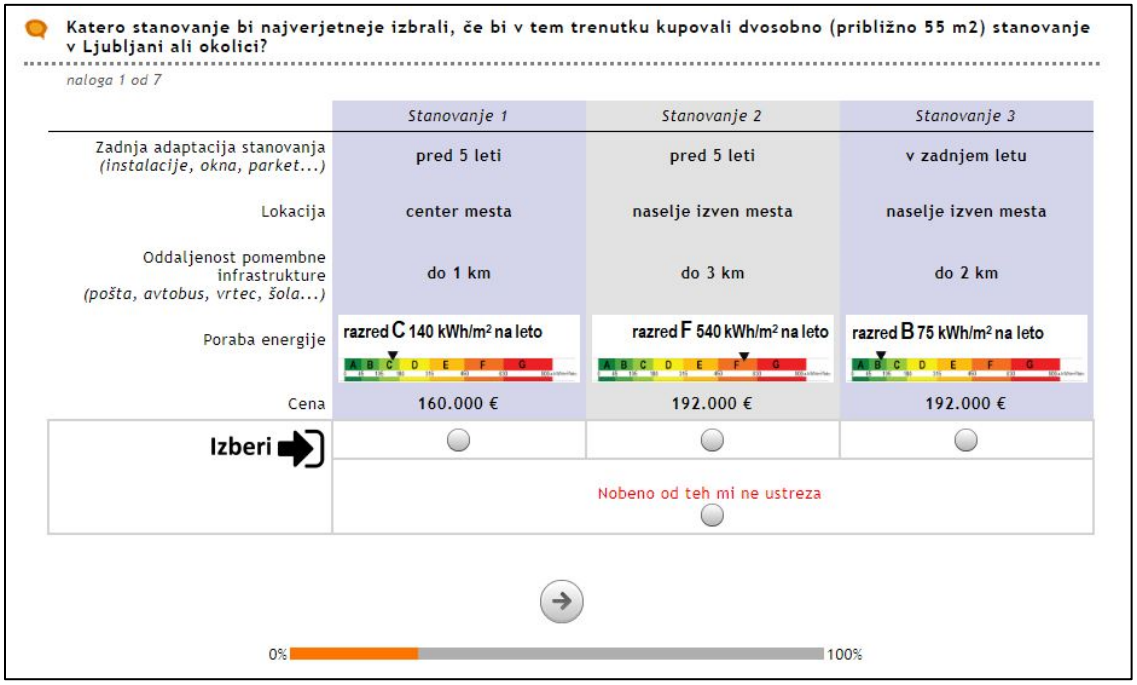

Figure 2.2.1 Screenshot showing a choice pair from the control group in the property DCE

Figure 2.2.2 outlines a similar choice set for the treatment group. In this scenario, the energy consumption (*Poraba energije*) is provided in terms of Euros. The experimental layout is identical in all other aspects.

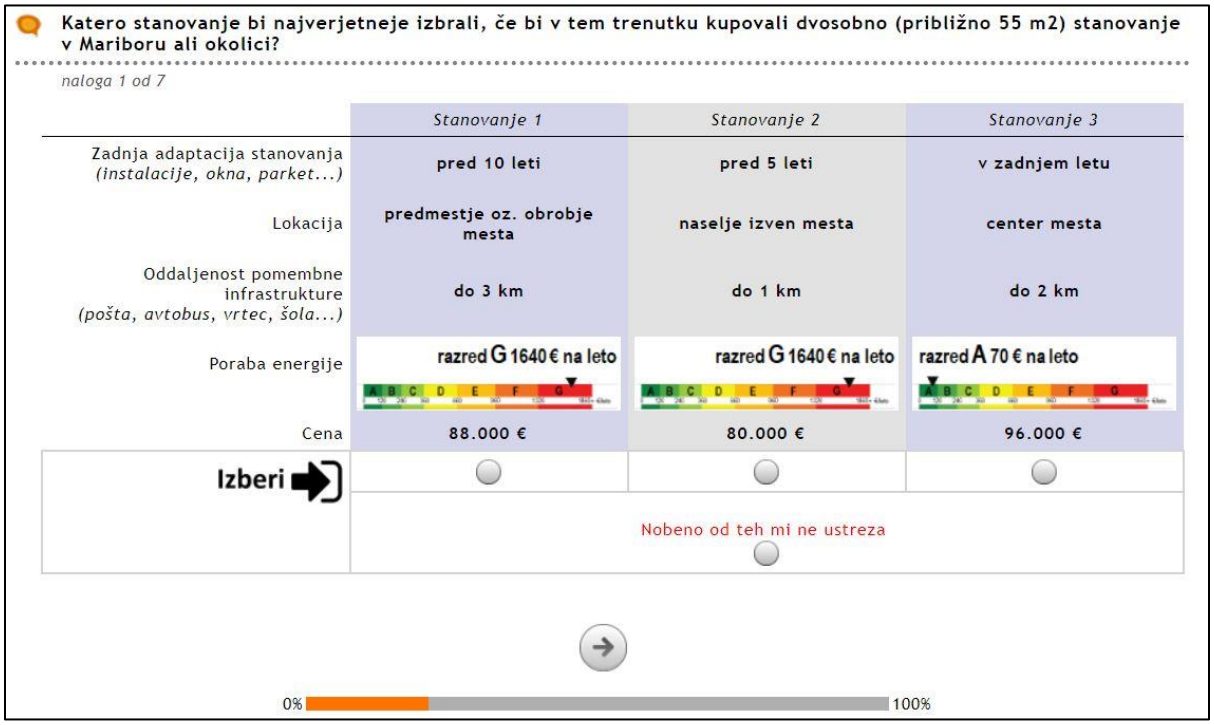

Figure 2.2.2 *Screenshot showing a choice pair from the treatment group in the property DCE*

Results

Table 2.2.2 presents a comparison of the control and treatment samples in terms of age, gender, and stated environmental concern (calculated from a Likert statement, as with the Norwegian study). While there is no statistical difference (two-sided mean comparison t-test) in age ($p = 0.763$), environmental concern is higher in the treatment group ($p = 0.014$) and the proportion of females is higher in the control group ($p = 0.103$, proportion test based on the normal distribution).[2]

[2] H_0: mean X = mean Y

Table 2.2.2 Key characteristics of control and treatment samples from the property DCE

	Control	Treatment
Respondents	226	200
Mean age (years)	42.4	42
Female share	69.03%	61.50%
Mean environmental concern (1-4)	2.74	2.95

The results of the conditional logit model estimated for the Slovenian property DCE are presented in Table 2.2.3. This model was estimated in NLogit. As with the Norwegian model, the cost and energy variables are modelled as continuous variables, whilst the location and condition variables are dummy modelled. A continuous energy efficiency variable is simply a seven-level variable (coded one through seven, for each efficiency grade in the experiment). The coefficient of this variable describes the average marginal utility of efficiency across the full efficiency range. For the dummy variables the reference variables are the distance furthest from the city centre and the oldest dwelling, for location and condition respectively. Our models include an alternative specific constant for the "neither" option only. As this is an unlabelled choice experiment with randomised alternatives, we would not expect any utility differences between alternatives which would warrant the inclusion of all alternative specific constants.

The results of this model indicate that the majority of variables are highly statistically significant, with the primary variables of interest, the energy efficiency and the cost, being significant at levels of $P<0.01$. In addition, the signs of all the parameter estimates can be considered to be intuitively correct, with increases in both cost related reduced utility, and increases in levels of energy efficiency linked to increases in utility. The condition of the dwelling was also found to be significant, with an increase in utility found to be associated with newer houses, for each level examined. The relationship between distance and utility is weaker, with only Distance 3 found to be significant, with respect to the reference parameter.

Table 2.2.3 Conditional logit results from the property DCE

	Value	Std Err	z
Cost	-0.19060D-04***	.1048D-05	-18.19
Energy Efficiency	0.16668***	.01700	9.80
Interaction of treatment and energy efficiency	0.07718***	.02488	3.10
Treatment	-0.20183	.14295	-1.41
Location_2 (level suburb)	0.29380***	.05572	5.27
Location_3 (level outside city)	0.09917*	.05723	1.73
Condition_2 (level 5yrs ago)	0.60434***	.07504	8.05
Condition_3 (level 10yrs ago)	0.92017***	.07261	12.67
Condition_4 (level 20yrs ago)	1.06012***	.07126	14.88
Distance_2	0.02797	.05583	.50
Distance_3	0.09376*	.05688	1.65

Table 2.2.4 shows the respective willingness to pay estimates for both the control and treatment groups. These results indicate a significantly higher willingness to pay for energy efficiency within the treatment group €12,794, in comparison to €8,745 within the control group. This represents a 46.3% increase in the valuation of energy efficiency when monetary estimates are included, with respect to the control group.

Table 2.2.4 Willingness to pay estimates from the control and treatment groups in the property DCE

MNL Model	WTP (euro)	Stand Err	Z	Confidence Interval
Control	8,745***	962	9.1	6,859 to 10,631
Treatment	12,794***	1,127	11.35	10,584 to 15,004

Impact of Gender

The role of gender has previously been highlighted as important in energy efficient investments. With regards to the Norwegian study, Table 2.2.5 outlines the results of an analysis of the differences in respective willingness to pay values arising from the conditional logit model, based upon the gender split within the sample. While treated males and females show a higher WTP for energy efficiency, the difference is only significant for the female sample. It can therefore be concluded that the higher WTP for

treated households observed in the total sample is partly driven by the relatively larger effect for females and also the higher share of females in the survey.

Table 2.2.5 Willingness to pay estimates from the control and treatment groups in the transport DCE

	WTP (euro)	Stand Err	Z	Confidence Interval
Male Sample:				
Control	8,100***	1,552	5.22	5,059 to 11,141
Treatment	10,828***	1,567	6.91	7,756 to 13,899
Female Sample:				
Control	9,070***	1,230	7.37	6,658 to 11,481
Treatment	14,082***	1,566	8.99	11,013 to 17,151

Policy implications

Based upon the findings arising from this experiment, it appears to be clear that consumers' willingness to pay for increased levels of energy efficiency can be increased by providing energy cost estimates in Euros, rather than the current approach of providing energy consumption estimates in terms of kilowatt hours per metre squared.

From a policy perspective, this increase in the willingness to pay for increased energy efficiency may have knock on effects, in terms of increased premiums for properties with higher energy ratings, and therefore an incentive for home owners to invest in energy efficiency improvements to increase the value of their property.

2.3 Household appliances DCE in Greece

The purpose of the DCE in Greece is to estimate the willingness to pay for more energy efficient refrigerators, and how this willingness is influenced by how energy information is displayed. As with the previous studies, the study relies on a split-sample design to test the impact of additional information on estimated cost of energy use per year alongside the mandatory EU label on physical energy use (kWh per year), as well as the impact of the way that information is presented.

Attributes and levels

Based on the focus groups with Greek consumers (see Deliverable 2.1 from CONSEED) we identified five critical parameters, namely price, energy class, energy consumption, fresh food compartment capacity and frozen food compartment capacity. For each of these five attributes we identified reasonable levels for the description of the refrigerators based on information obtained from various online sources. Considering that there is a considerable variation in the refrigerator market, we chose a bottom freezer with single door, which is the most commonly sold refrigerator in Greece, and used this as a mental model to help ensure a credible combination of the attribute levels.

- For the *price* six different levels are used (400, 450, 500, 550, 600, 650 Euros), which correspond to the actual range for this type of refrigerators, except the most expensive models.
- The *energy class* included three levels (A+, A++ and A+++). These three energy classes were used since the consumer survey that was conducted in Greece showed that approximately 80% of the existing refrigerators, as declared by the respondents, are of A+ class or higher.
- The *energy consumption* also involved three levels, 165, 240, and 315 kWh/year (a differential consumption of 75 kWh/year between the levels, equivalent to approximately 10 Euros per year).
- The *fresh food compartment capacity* was used as a proxy for the size of the refrigerator with three levels, i.e. Low (220 – 235lt), Medium (237-255lt) and High (265-280lt).
- The *frozen food compartment capacity* was also included in the design for the same reason with two levels, namely Low (86-89lt) and High (92-98lt).

Table 2.3.1 Attributes and levels for the appliances DCE

Price (Euros)	Energy class	Energy consumption (kWh/year)	Fresh food compartment capacity (lt)	Frozen food compartment capacity (lt)
400	A+	165	Low (220-235lt)	Low (86-89lt)
450	A++	240	Medium (237-255lt)	High (92-98lt)
500	A+++	315	High (265-280lt)	
550				
600				
650				

Design

The experiment was designed using a split sample approach. More specifically, the respondents were randomly assigned (with equal probability) to one of four experimental conditions (see Figure 2.3.1):

- A labeled experiment without additional information on the estimated cost of energy (Control sample)
- A labeled experiment with additional information on the estimated cost of energy (Treatment 1)
- A non-labeled experiment without additional information on the estimated cost of energy (Treatment 2), and
- A non-labeled experiment with additional information on the estimated cost of energy (Treatment 3).

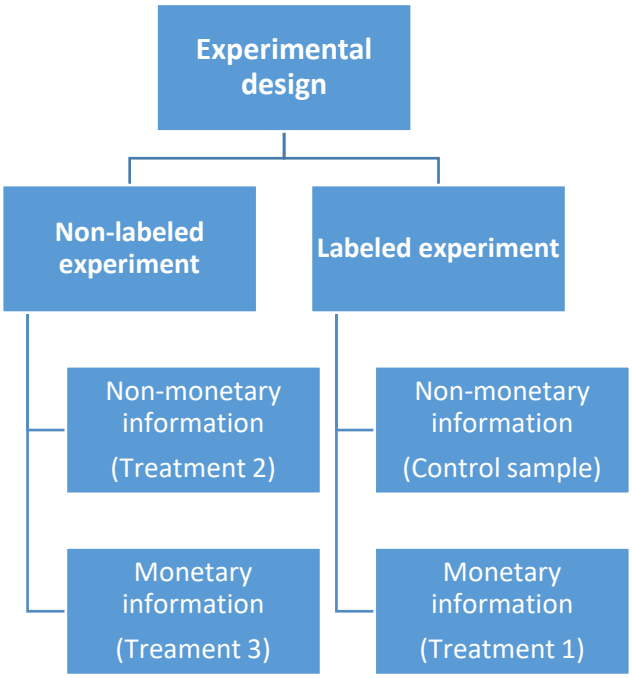

Figure 2.3.1 The design of the household appliance DCE

Based upon the selected attributes and predetermined priors, the experimental design was carried out using Street and Burgess's cyclical designs (Street at al. 2008) and the STATA dcreate module (Hole, 2015) that creates D-optimal designs using the modified Fedorov algorithm. Both designs were examined for their efficiency using the Street and Burgess's free software (The software is available for free at: http://130.56.248.113/choice).

Using Street and Burgess's approach, the design started with the OMEP 2^10 3^8 6^1, dropping the unnecessary attributes. These 36 treatment combinations became the profiles in Alternative A. To create the profiles in alternative B systematic level changes were made equivalent to adding the generator 11111 to the OMEP. The addition was performed in mod 2 for the two-level attribute, mod 3 for the three-level attributes and mod 6 for the six-level attribute. The resulting design consists of 36 choice sets, which are 93.60% efficient and all main effects are uncorrelated. The construction of the D-optimal design was carried out with no prior information of the true parameters of β. After conducting the pilot survey, the design could be re-checked using priors. Again 36 treatment combinations were set as minimum. The algorithm converged after six iterations giving D-efficiency 3.99994 with an efficiency of 99.46%. The latter was used in the experiment. The 36 choice sets, which included an "opt-out" option, were split into four blocks of nine to avoid respondent fatigue. These blocks were then replicated for both the control and treatment versions of the experiment. From the perspective of a given respondent, once they began the experiment they were allocated to either a control or treatment block, where they were asked to undertake nine choice scenarios.

Implementation

The survey was conducted in December 2017 by the survey Company Metron Analysis, which is a member of the Association of Greek Market & Opinion Research Companies (AGMORC) and the World Association for Public Opinion Research (WAPOR) and follows quality assurance procedures that have been certified by AGMORC's Data Collection Quality Control. The target group was the adult Greek population. In total, 992 questionnaires (248 questionnaires per experimental treatment condition) were successfully completed via CAWI (computer-assisted web interviewing). The response rate was 48%. About 50.2% of respondents were male, and all of them currently have a refrigerator in their household.

Figure 2.3.1 below shows an example of how the attributes and levels were combined to create choice pairs (2.3.1a showing a translated version and 2.3.1b the original Greek version).

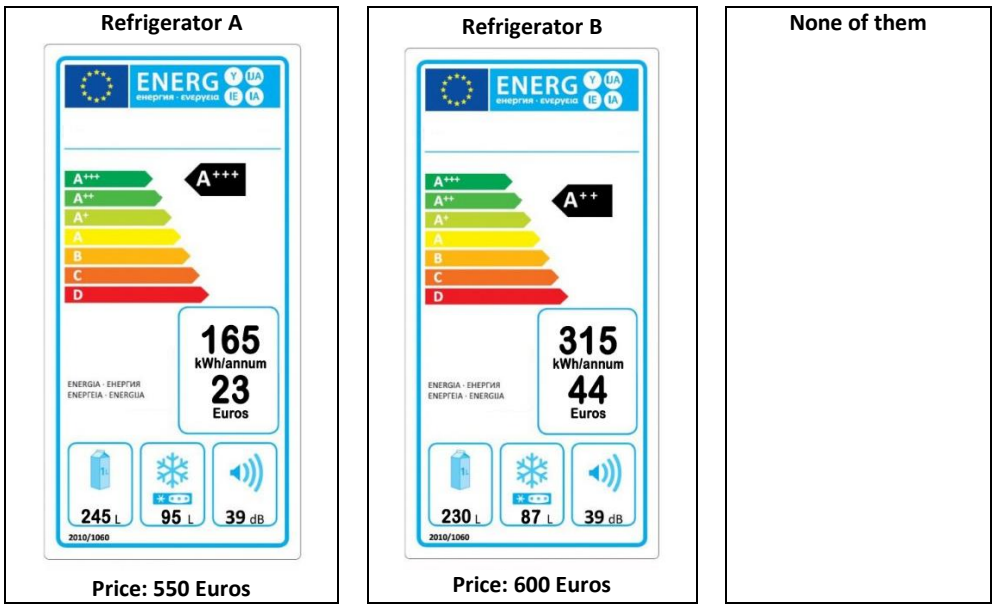

Figure 2.3.1a Screenshot showing a choice pair from treatment group 2 in the household appliance DCE (translated version)

Ψυγείο Α	Ψυγείο Β	Κανένα από τα δύο
		
Τιμή: 550 Ευρώ	Τιμή: 600 Ευρώ	

Figure 2.3.1b Screenshot showing a choice pair from treatment group 2 in the household appliance DCE (original Greek, version)

	Refrigerator A	Refrigerator B	None of them
Energy class	A+++	A++	
Fresh food compartment capacity	Medium (237-255 lt)	Low (220 – 235 lt)	
Frozen food compartment capacity	High (92-98 lt)	Low (86-89 lt)	
Annual energy consumption and cost	165 kWh 23 Euros	315 kWh 44 Euros	
Purchase price	550 Euros	600 Euros	

Figure 2.3.2a Screenshot showing a choice pair from treatment group 3 in the household appliance DCE (translated version)

	Ψυγείο Α	Ψυγείο Β	Κανένα από τα δύο
Ενεργειακή κλάση	Α+++	Α++	
Χωρητικότητα συντήρησης	Μεσαία (237-255 lt)	Χαμηλή (220 – 235 lt)	
Χωρητικότητα κατάψυξης	Υψηλή (92-98 lt)	Χαμηλή (86-89 lt)	
Ετήσια κατανάλωση ενέργειας και κόστος	165 kWh 23 Ευρώ	315 kWh 44 Ευρώ	
Τιμή αγοράς	550 Ευρώ	600 Ευρώ	

Figure 2.3.2b Screenshot showing a choice pair from treatment group 3 in the household appliance DCE (original Greek, version)

Results

Table 2.3.2 presents the characteristics of the respective control and treatment samples with regard to their age, gender, and stated levels of environmental concern (calculated from a Likert statement). These results show that the four samples can be considered to be very similar in composition, and that the levels of stated environmental concern did not vary significantly although the mean difference is statistically significant (means test for Age: Wald chi2(3) = 4.9, Prob > chi2 = 0.1783; means test for Environmental concern: Wald chi2(3) = 382.38, Prob > chi2 = 0.0000; proportion test for Female share: Pearson chi2(3) = 3.9194, Pr = 0.270).

Table 2.3.2 Key characteristics of control and treatment samples from the property DCE

	Control	Treatment 1	Treatment 2	Treatment 3
Respondents	248	248	248	248
Mean age (years)	40.4	40.2	40.5	40.6
Female share	49.19%	49.59%	50.08%	49.59%
Mean environmental concern (1-4)	3.44	3.33	3.23	3.21

Towards analysing the mean WTP for energy efficiency improvements, a conditional logit (CL) model with interactions was considered that included the monetary information (dummy variable: cost information is included = 1; 0 otherwise), the label information (dummy variable: information presented

as label = 1; 0 otherwise) and gender (male = 1; female = 0) as interaction terms with the consumption variable. More specifically, the following utility function for alternative i, where the alternative simply represents a certain state of the world, and respondent k was used:

$$V_{ik} = \beta_0.ASC + \beta_1.Energy\_class2 + \beta_2.Energy\_class3 + \beta_3.Fresh\_food\_capacity2 + \beta_4.Fresh\_food\_capacity2 + \beta_5.Frozen\_food\_capacity + \beta_6.Consumption + \beta_7.Price + \beta_8.Consumption \times Cost\_info + \beta_9.Consumption \times Label\_info + \beta_{10}.Consumption \times Male$$

where β are the parameters of choice attributes to be estimated

The marginal WTP for energy efficiency improvements with respect to monetary information, label information and gender is estimated as follows:

$$MWTP_{monetary\_info} = -\frac{\partial v_{vik}/\partial Consumption}{\partial v_{vik}/\partial Price} = -\frac{\beta_6 + \beta_8.Consumption \times Cost\_info}{\beta_7}$$

$$MWTP_{label\_info} = -\frac{\partial v_{vik}/\partial Consumption}{\partial v_{vik}/\partial Price} = -\frac{\beta_6 + \beta_9.Consumption \times Label\_info}{\beta_7}$$

$$MWTP_{gender} = -\frac{\partial v_{vik}/\partial Consumption}{\partial v_{vik}/\partial Price} = -\frac{\beta_6 + \beta_{10}.Consumption \times Male}{\beta_7}$$

Hence, it is possible to estimate multiple values for the Consumption attribute, e.g. one can estimate one value for women, which will be the ratio of the attribute coefficient to the marginal utility of money and a second value for men, which will be the ratio of the sum of the attribute coefficient plus the interaction term to the marginal utility of money.

The results of the conditional logit model based upon the Greek discrete choice experiment are presented in Table 2.3.3. The price and energy consumption variables have been modelled as continuous variables, whereas the fresh food compartment capacity, the frozen food compartment capacity and the energy class variables are dummy coded, with the lowest level taken as the reference level. Moreover, three interaction variables were created to test whether the display of the cost of energy consumption, the way the information is presented, and the gender affect the results.

These results indicate that all the variables included but the '*Consumption x Cost information*' interaction variable were found to be highly statistically significant. In addition, the sign of parameters are as expected, with increases in price and energy consumption leading to decreases in utility, while increases in energy class and fresh and frozen food compartments capacity are linked with increased levels of utility. The label information and the gender interaction variables also emerged as being highly statistically significant, indicating that the way that information is presented has a detectable effect on consumer choices. On the contrary, the monetary information was statistically insignificant.

Table 2.3.3 Conditional logit results from the household appliance DCE

	Value	Std. Err.	z
ASC	2.6127***	0.1250	20.91
Energy_class2 (level: A++)	0.5247***	0.0363	14.44
Energy_class3 (level: A+++)	1.0188***	0.0364	28.01
Fresh_food_capacity2 (level: medium)	0.4204***	0.0364	11.55
Fresh_food_capacity3 (level: high)	0.7473***	0.0369	20.24
Frozen_food_capacity (level: high)	0.3881***	0.0268	14.48
Consumption	-0.0062***	0.0003	-19.95
Price	-0.0030***	0.0002	-14.63
Consumption x Cost_info	0.0002	0.0002	0.95
Consumption x Label_info	-0.0009***	0.0002	-4.01
Consumption x Male	0.0007***	0.0002	3.14

Table 2.3.4 outlines the willingness to pay values (euros per kWh reduced consumption) for the control and treatment groups within the sample. The results show that the value for a one kWh decrease in energy consumption decreases when the cost information is revealed to the respondents. To wit, the decrease in WTP between the Control group and Treatment 1 is approximately 2.5%, and between the Treatment 2 and 3 groups is around 23%, respectively. Nevertheless, consistent with the results of the econometric model, there is no statistically significant difference between the groups as determined by t-test statistics.

Table 2.3.4 Willingness to pay estimates from the control and treatment groups in the household appliance DCE

	WTP (euros per kWh reduced consumption)	Stand Err	Z	Confidence Interval
Control	2.28***	0.1768	12.94	1.94 to 2.64
Treatment 1	2.21***	0.1724	12.84	1.88 to 2.55
Treatment 2	1.98***	0.1591	12.45	1.67 to 2.29
Treatment 3	1.91***	0.1550	12.30	1.60 to 2.21

Impact of Gender

As regards to the Greek study, Table 2.3.5 outlines the results of the analysis of the differences in respective WTP values arising from the conditional logit model, based upon the gender split within the sample (control and treatment groups). These results demonstrate that, for all the control and treatment samples, there is a significant difference (in the case of Treatments 1 and 3 where cost information is included in the experiment, the coefficient of the interaction variable is not statistically significant at 5%) between the valuations of energy efficiency observed, with females demonstrating a higher valuation for EE than males.

Table 2.3.5 Willingness to pay estimates the control and treatment groups in the household appliance DCE

	WTP (euros per kWh reduced consumption)	Stand Err	Z	Confidence Interval
Male Sample:				
Control	2.01***	0.2559	7.86	1.51 to 2.51
Treatment 1	2.03***	0.3253	6.23	1.39 to 2.66
Treatment 2	2.19***	0.3889	5.64	1.43 to 2.96
Treatment 3	1.73***	0.2807	6.16	1.18 to 2.28
Female Sample:				
Control	2.27***	0.2826	8.03	1.71 to 2.82
Treatment 1	2.13***	0.3365	6.32	1.47 to 2.79
Treatment 2	2.61***	0.4486	5.82	1.73 to 3.49
Treatment 3	1.97***	0.3079	6.38	1.36 to 2.57

Policy implications

The results arising from this experiment indicate a decrease in the willingness to pay for energy savings when labels accompany energy information with monetary estimates. However, it should be mentioned that the interaction variable is statistically insignificant. This indicates that including monetary energy cost estimates in the refrigerator energy labels would not probably affect the consumers' choices due to the relatively low annual operating cost of the refrigerator. Thus, from a policy perspective, energy efficiency campaigns should focus better on other benefits, e.g. contribution of households to climate change mitigation due to lower greenhouse gases emissions. As far as the role of gender is concerned,

similar to the transportation DCE, women seem to demonstrate a higher valuation for EE than males/ Less clear results emerge regarding the impact of the treatment by gender.

3 Conclusion

Energy labelling has resulted in more energy efficient products offered on the market, bringing about both energy and cost savings. However, while these (mandatory) labels are now used across Europe, much less is known about how consumers interact with these labels and how they affect the relative importance of energy consumption in the decision-making process. To investigate whether displaying monetary cost information on appliances, property and transport would further encourage investment in EE, we conducted three DCEs (in Greece, Slovenia, and Norway, respectively).

The DCEs on property and transport are similar in experimental design, and both show large and statistically significant increases in the WTP in the treatment condition. The absolute results thus superficially appear similar. However, the absolute prices of the products differ substantially, and there is no meaningful comparison of a one-unit improvement in fuel efficiency (1l per 100 km) and in property energy use (one letter improvement in BER). We are therefore cautious about drawing strong inferences across the studies. The results from the household appliance DCE are not comparable to the other two as it relied on a nested split-sample design. The household appliance DCE showed a statically non-significant decrease in the willingness to pay when monetary energy information was shown to respondents.

Table 3.1 summarizes the willingness to pay estimates from all three DCEs (NOK converted to Euro at a rate of 9.7:1).

Table 3.1 Willingness to pay for control versus treatment groups for transport and property

	Cars	Property	Household appliances
Control WTP	€8,890	€8,745	€2.28
Treatment WTP	€10,583	€12,794	€2.20 / €1.98 / €1.91
Percentage Increase	19%	46.3%	-3.5%$^{N.S.}$ / -13.2%$^{N.S.}$ / -16.2%$^{N.S.}$

To test that our policy conclusions are robust to alternative specifications we also analysed the Norwegian and Slovenian data using a mixed logit model. While energy efficiency WTP estimates from the mixed logit model are different in magnitude, the interaction term remains statistically significant and the percentage increase in treatment WTP is unaffected. Our conclusions are therefore robust to this alternative model[3].

In all three DCEs we find that women have a higher willingness to pay for energy efficiency. The interactions between gender and the treatments are, however, less straightforward. In the Norwegian DCE men increased their willingness to pay by more than women, whereas the opposite was true in the Slovenian DCE, and with non-significant results in the Greek DCE.

[3] For the mixed logit specification we assumed a normal distribution for EE, cost and the alternative specific constant ('neither' option) and estimated with 200 Halton draws

4 References

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5 Appendices

Appendices A, B and C provide the questionnaires used in the DCEs on transport, properties and household appliances, respectively.

5.1 Appendix A: Questionnaire used in the transport DCE in Norway

Introductory text

The study concerns purchasing or leasing a new car.

The study is part of a research project funded by the EU and will provide insights into your views on important questions.

It will require 10-12 minutes to complete the study.

Screening questions

Has your household ever purchased or leased a new car from a dealership? [Yes; No]

[Screening question 2 asked if respondent answered "No" to screening question 1]

Are you planning to purchase or lease a new car from a dealership within the next 12 months? [Yes; No]

How involved were you in this decision? [Very much involved; Involved; Not involved]

Background questions

Does your household current have access to a car? [Yes; No]

[Background question 2 asked if household has access to car]

What type of fuel does the car you have access to use? If you have access to more than one car please answer for the car you use the most. [Gasoline; Diesel; Electricity; Gasoline and electricity (hybrid); Diesel and electricity (hybrid); Other (biogas, natural gas, etc.)]

Introductory text to DCE part of survey

We want to explore how much weight you place on different factors when you choose a new car. In the first eight questions we will ask you to choose between two car models. The following factors vary between the models:

- Price
- [For control group only] Fuel consumption per 100 km
- [For treatment group only] Fuel consumption per 100 km and fuel cost per month
- Boot capacity
- Safety

We ask you to pay attention to all the information and tick the box for the car you would prefer if the choice was limited to the two models shown.

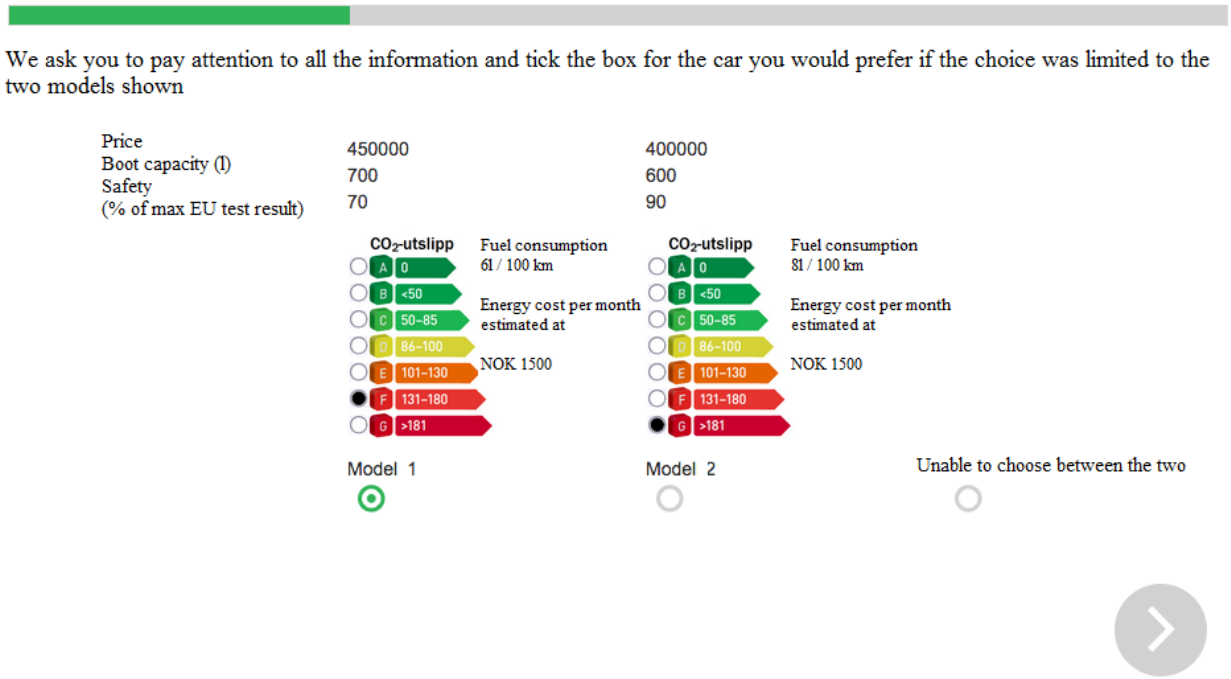
[For treatment group only] The calculation of the fuel cost per month is based on a gasoline price of NOK 14 per liter, the EU test procedure for estimating energy use (NEDC) and an annual mileage of 15,000 km (i.e. 1250 km per month).

We ask you to assume that the two car models are otherwise identical, i.e. that they have the same handling, number of seats, equipment level etc.

There are no right or wrong answers

Figure 5.1.1 shows a translated version of a screenshot from the online survey, illustrating what the choice pairs looked like to respondents.

Figure 5.1.1 Screenshot of a choice pair in the treatment condition.



5.2 Appendix B: Questionnaire used in the property DCE in Slovenia

Introductory text

The study is part of a research project funded by the EU and will provide insights into your views on important questions. It will require 8-10 minutes to complete the study.

Screening questions

Do you currently own property in Slovenia? [Yes; No]

Will you purchase house or apartment in next 3 years? [Yes; No]

What type of property will you purchase? [House; Apartment; Do not now]

How involved are you in decisions relating to your past or future property decisions? [Very; Slightly; Not at all]

Background questions

Imagine buying a property (an apartment or a house).

How important is each of these characteristics for you? [not at all important; not very important; fairly important; very important; don't know]

- state of the property (when the property was last renewed)
- distance from your service or faculty
- distance of important infrastructure (kindergarten, school, post office, bus)
- energy efficiency (e.g. quality of insulation, windows, mode of heating)
- size
- price

Introductory text to DCE part of survey

**Note: Choice experiment was shown only to the respondents who indicate that intend to buy house/apartment in or near the one of the preselected cities.*

We want to explore how much weight you place on different factors when you are buying a property.

Imagine that you are buying a two-bedroom apartment in the "*Name of the city"* or the surrounding area.

We will show you several offers of apartments, three at a time. All apartments are two-bedroom, have the same square footage (55 m2) and the same arrangement. Take a look at each offer, think about which apartment meets your criteria and capabilities and choose the one that suits you best.

Dwellings will differ only in the following qualities:

1) Condition (last adaptation of the property - installations, windows, parquet):

- Brand new
- 5 years ago
- 10 years ago

- 20 years ago

2) Location

- City center
- Suburbs (the outskirts of the city)
- Outside the city

3) Distance from important infrastructure (bus, post office, kindergarten, school ...)

- 1 km
- 2 km
- 3 km

4) Energy certificate

- Show all cards [(kWh/ m2)/per year or €/per year]

5) Price (view is related to the desired place of purchase)

- 80% (e.g. € 128,000 for Ljubljana)
- 90% (e.g. € 144,000 for Ljubljana)
- 100% (e.g. € 160,000 for Ljubljana)
- 110% (e.g. € 176,000 for Ljubljana)
- 120% (e.g. € 192,000 for Ljubljana)

5.3 Appendix C: Questionnaire used in the household appliances DCE in Greece

Introductory text

The study concerns purchasing a new refrigerator.

The study is part of a research project funded by the EU and will provide insights into your views on important questions.

It will require 12-15 minutes to complete the study.

Screening questions

How involved were you in the choice of your current refrigerator? [Very much involved; Involved; Not involved]

Background questions

How much money do you pay on your electricity bill per year for the operation of your refrigerator? [Open-ended answer; Don't know]

Imagine buying a new refrigerator.

How important is each of these characteristics for you? [not at all important; not very important; fairly important; very important; don't know]

- Price
- Fresh food compartment capacity
- Frozen food compartment capacity
- Electricity consumption
- Energy class (energy efficiency)
- Design
- Reliability of the manufacturer
- Warranty
- After-sales service
- Operation cost
- Other

Introductory text to DCE part of survey

We want to explore how much weight you place on different factors when you choose a new refrigerator. In the first nine questions we will ask you to choose between two refrigerators. We ask you to assume that the two refrigerators are identical (i.e. brand, colour, warranty, noise level, etc.) and differ only in the following factors:

- Price [400, 450, 500, 550, 600, 650 Euros]
- Energy class [A+, A++, A+++]
- Fresh food compartment capacity [Low (220 – 235lt), Medium (237-255lt) and High (265-280lt)]
- Frozen food compartment capacity [Low (86-89lt) and High (92-98lt)]
- [For control group only] Energy consumption per year in kWh [165, 240, and 315 kWh/year]

- [For treatment group only] Energy consumption per year [in kWh] and energy cost per year [165, 240, and 315 kWh/year, i.e. the differential consumption of 75 kWh/year between the levels, equivalent to approximately 10 Euros per year]

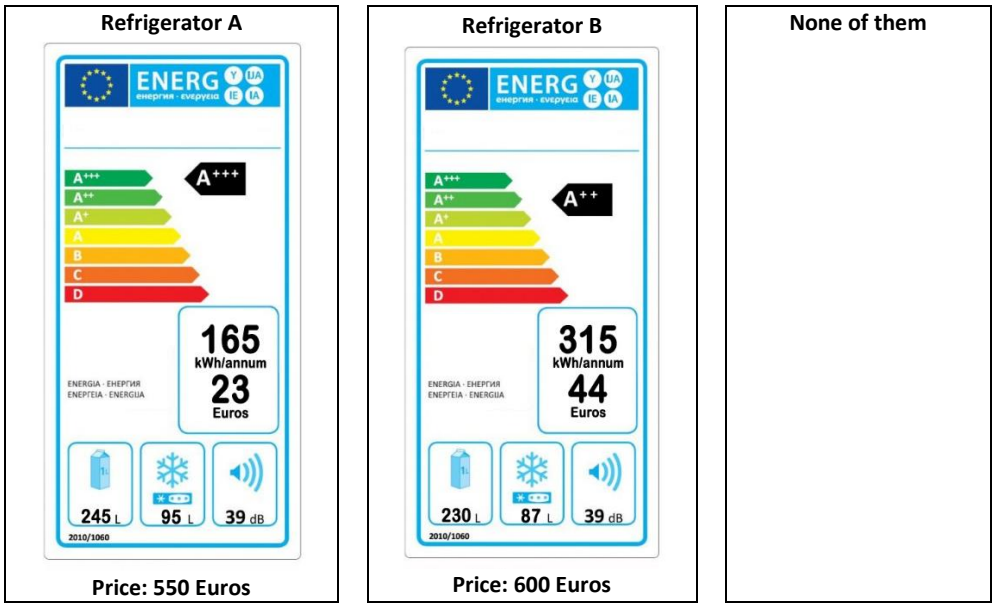
We ask you to pay attention to all the information and tick the box for the refrigerator you would prefer if the choice was limited to the two models shown.

[For treatment group only] The calculation of the electricity cost per year is based on the average electricity price in Greece and the electricity consumption of each refrigerator.

There are no right or wrong answers

[Figure A.1 shows a translated version of a screenshot from the online survey, illustrating what the choice pairs looked like to respondents.]

Figure A.12 Screenshot of a choice pair in the treatment condition.



Follow-up question to DCE

When you were choosing a refrigerator, how important was each of the following factors for you? [not at all important; not very important; fairly important; very important; don't know]

- Price
- Energy class
- Fresh food compartment capacity
- Frozen food compartment capacity
- Energy consumption per year