CONSEED

CONSumer Energy Efficiency Decision making

DELIVERABLE 5.1

REPORT ON THE VALIDATED ENERGY INVESTMENT MODEL

June 10th, 2019

Document info

Project Number	723741- CONSEED
Funding Scheme	H2020-EE-2016-17, Topic EE-08-2016, Research and Innovation Action (RIA)
Work Programme	CONSumer Energy Efficiency Decision making (CONSEED) is an EU-funded research project that studies how consumers use information on energy usage when they buy a house, car or an appliance
Number	Deliverable 5.1
Title	Report on the validated energy investment model
Dissemination Level	Public
Date	June 10, 2019 (M31)
Nature	Report
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Reviewers	

Document History

Date	Action	Status
01.03.2019	Preparation of the 1st draft by AUA partners	Complete
05.03.2019	Written feedback from TCD partners	Complete
06.03.2019	Written feedback from CICERO partners	Complete
11.03.2019	Written feedback from BC3 partners	Complete
13.03.2019	Written feedback from UL partners	Complete
20.03.2019	2rd draft prepared by AUA	Complete
12.04.2019	Discussion at plenary	Complete
22.04.2019	3nd draft prepared by AUA and issued to all partners	Complete
10.05.2019	Final version drafted	Complete
10.06.2019	Final version submitted	Complete

CONSumer Energy Efficiency Decision making is an EU-funded research project that studies how consumers use information on energy usage when they buy a house, car or an appliance. Funded by the European Union's Framework Programme for research and innovation Horizon 2020 under grant agreement number 723741.

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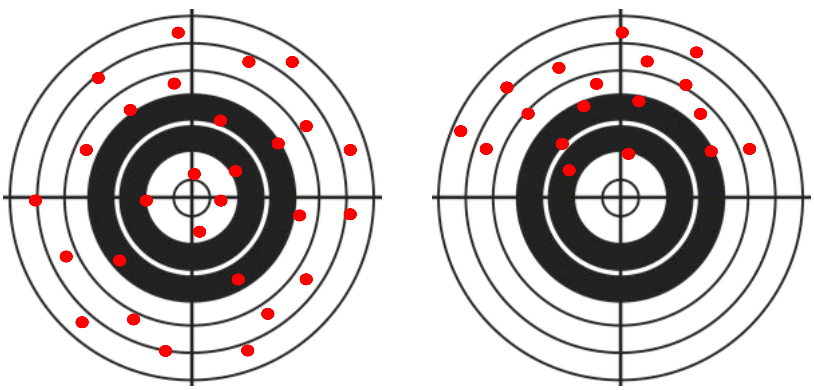
Executive summary

The general aim of the CONSEED Project is to examine how different consumer groups interact with existing energy efficiency (EE) policies that aim to influence consumer investment decisions, and to make policy recommendations based on the empirical evidence collected. The objective of CONSEED WP 5 is to combine the results of WPs 1 to 4 to validate, refine and develop further the consumer decision making models and estimate implicit discount rates.

The CONSEED partners initially set out to design surveys, discrete choice experiments and field trials in a harmonized way to facilitate subsequent data pooling. However, for the reasons detailed in Section 2.1, two homogenized datasets were finally created, which were used for validation purposes, namely for households and firms.

The main conclusions drawn from the validation process are as follows:

According to statistical measures of predictive accuracy and of calibration performance, the regression model used is the correct one, the pooled models derived for the households and the firm samples pass the internal validation tests. Further, given the larger number of observations and the diverse nature of the population, the pooled samples seem to allow for a more reliable investigation of the relative importance of the factors influencing consumers' attitudes and beliefs towards energy investment decisions.



Valid model | Not valid model

Based on the statistical tests conducted in order to evaluate the 'transferability' of the pooled models (i.e. the possibility of creating a 'universal' model of EE from the pooled model), it can be argued that the models are transferable in specific cases. For instance, as regards households, the null hypothesis that all the coefficients in the Appliances and Properties models are equal cannot be rejected. The same outcome is observed for the Appliances and Properties when using the pooled sample from the firms. In some situations, the lack of transferability may be attributed to the fact that the importance of EE varied between the samples, as mentioned in Deliverable 3.1. For instance, for household appliances, EE was among the top two factors (more than 70% rate is as very important). For personal cars, EE was ranked only fourth. The same conclusion was drawn for tractors in agriculture. The difference with the results for commercial is even larger, with only 26% rating EE as very important. In general, non-household groups paid more attention to other attributes such as reliability.

The pooled models confirm the findings of the individual models developed in Deliverable 3.1. With regards to household sector attitudinal factors (e.g. household's contribution to environmental impacts reduction, willingness to take a chance on new technologies to reduce energy consumption, awareness of energy prices, understanding of energy savings from energy efficient appliances, etc.) and demographic characteristics (i.e. gender), play a significant role in beliefs about EE. Most importantly for the role of CONSEED, those who claim that energy labels would affect their choice are more likely (11%) to value the EE attribute as very important. Similarly, in agricultural and services sectors, the importance of EE is affected by attitudes such as the willingness of businesses to reduce their impact on the environment or the willingness to take a chance on new technologies so as to reduce their energy consumption, and the awareness about energy savings from energy efficient appliances. Those affected by the energy labels are more likely to value EE as a very important attribute when considering energy investments, but at a lower rate compared to households (i.e. 4.6%).

In conclusion, although the pooled models are validated, any extrapolation of the above-mentioned findings to specific populations in terms of 'space' (i.e. country) and 'target' (e.g. sectors and technologies) should be approached with caution from a policy perspective.

1 Introduction

The objective of CONSEED Work Package 5 is to validate, refine and develop further the consumer decision making models and estimate implicit discount rates by combining the results of WPs 1 to 4. The specific objectives are to:

- Identify constraints and opportunities of pooling revealed and stated preference data for use in the developed consumer investment decision model(s) (Task 5.1)
- Apply state-of-the-art econometric techniques in validating a priori expectations of the model(s) (Task 5.2)
- Use direct and indirect approaches in estimating implicit discount rates in energy investment decisions (Task 5.3).

This deliverable concerns the first two of the three bullet points. A separate deliverable 5.2 reports on the results of implicit discount rates in energy investment decisions.

More specifically, as a first step, all the datasets collected in the different consumer surveys, field trials and discrete choice experiments across a range of consumer groups, product categories and geographical locations were examined and cleaned so as to be made suitable to pool (Task 5.1) for econometric analysis. This resulted in two homogenized datasets, as detailed in Section 2.1. The two datasets were used to validate the theoretical model and determine the relative importance of each factor in the energy investment decisions, following the validation methodology (discussed in Section 2.1). In order to have a common framework of analysis, the theoretical and econometric models tested are based on the models developed in Deliverable 3.1. Binary response (probit) models are constructed based on the probability of having answered 'very important' to the energy efficiency (EE) question. More specifically, the applied probit models can be expressed as: $P(y=1|X)$ where y is "*Energy Efficiency is a Very Important attribute in the purchasing decision*" and X contains explanatory variables referring to respondents' attitudes towards EE, perceptions of the existing labels, economic incentives, socio-demographics, etc. The results for the two pooled datasets are presented in sections 3 and 4, respectively. Finally, in Section 5, we present the main conclusions drawn from the analysis.

2 Methodology

2.1 Sample pooling

The CONSEED partners initially set out to design surveys, discrete choice experiments and field trials in a harmonized way to facilitate subsequent data pooling (Table 1). However, the considerable heterogeneity in field trials and discrete choice experiments lead to inconsistency in variables and contexts which prevented pooling of these datasets. For example, while the results of the property and appliance field trial are comparable in terms of their treatment effects, it is not feasible or desirable to combine these two datasets in a consistent manner for ex-post analysis and verification purposes due to the very different characteristics of each dataset. Furthermore, while each discrete choice experiment included EE as an attribute, all remaining attributes differed by the technology explored, as did the experimental designs and treatment methods. Given the heterogeneity of the field trials and discrete choice experiments, pooling would not produce a workable dataset.

Of the available data types, only the consumer surveys are suitable for pooling and analysis. Despite considerable differences in locations (Greece, Ireland, Spain, Norway and Slovenia), technologies (property, appliances, transport, machinery) and sectors (households, services, agriculture, industry), CONSEED designed a 'core' set of survey questions which were applied in all surveys. Often this required minor adjustments depending on the sample and context. For example, when asked about the importance of technology attributes, the set of six attributes always included energy/fuel efficiency/consumption and price, but partners had discretion in choosing four additional sample-specific attributes. In relation to attitudinal questions, the following example demonstrates the consistency and the nature of setting-specific discretion with regard to question phrasing (note: text in italics is interchangeable and depends on the technology and sector explored):

> "In relation to EE in the *home*, please state whether you disagree or agree with the following statements:
>
> 1. Buying a more energy efficient *property* would reduce my *household's* environmental impact
>
> 2. All new *properties* have similar EE levels
>
> 3. More energy efficient *appliances* are less reliable"

In addition to this, partners had discretion in asking supplementary non-core questions in their surveys.

The resulting "pooled" dataset incorporates all core survey questions only, covering households, firms and farmers. A list of common questions is available in Appendices I and II.

Table 1. Total CONSEED samples

Survey	Country	Level	Sector	Technology	Data collection method	Type of data	Sample size
Consumer surveys	ES	National	HHs	Appliances	CAPI	Stated	500
	GR	National	HHs	Appliances	CAWI	Stated	496
	IE	National	HHs	Property	CAWI	Stated	501
	SL	National	HHs	Property	CAWI	Stated	426
	NO	National	HHs	Transport	CAWI	Stated	1,093
	ES	National	Services	Appliances	CATI	Stated	200
	GR	National	Services	Appliances	CATI	Stated	102
	IE	National	Services	Property	CATI	Stated	187
	IE	National	Agriculture	Machinery	CAWI	Stated	316
	SL	National	Industry	Machinery	CAWI	Stated	83
	NO	National	Industry	Machinery	CAWI	Stated	86
Field Trials	ES	Local	HHs	Appliances	Information collected from 26 small retailers	Revealed	Washing-machines: 1,433 Fridges: 854 Dishwashers: 430
	IE	National	HHs	Property	Centralized online property portal	Revealed	Asking Price Control: 27,581 Treatment: 45,451 Closing Price Control: 6,847 Treatment: 13,308 Rents Control: 13,011 Treatment: 30,163
	NO	Local	HHs	Transport		Revealed	-

DCEs	NO	National	HHs	Transport	CAWI	Stated	Control: 555 Treatment: 538
	SL	National	HHs	Property	CAWI	Stated	Control: 226 Treatment: 200
	GR	National	HHs	Appliances	CAWI	Stated	Control: 248 Treatment 1: 248 Treatment 2: 248 Treatment 3: 248

Note: *CAPI - Computer Assisted Personal Interviewing; CAWI - Computer Assisted Web Interviewing; CATI - Computer Assisted Telephone Interviewing*

2.2 Model validation

Model validation is a statistical concept that hints at the model's degree of generalizability. It assesses - in a quantitative and objective manner - how well the estimated model will predict on an *independent* sample of similar data. The terms '*model reliability*' and '*model validity*' are often used interchangeably although they connote two different things.

Reliability (sometimes referred to as verification) refers to the degree of reproducibility of the results (any results). In other words, a reliable model yields consistent results. Nevertheless, a reliable model is not necessarily valid.

Validity refers to the degree to which the method is truly measuring what the researcher intended it to (John and Benet-Martinez 2014). To put it differently, a valid model implies that the model chosen for measuring the theoretical concepts and relationships represents accurately the real-world phenomena.

Effective verification and validation of a model will increase the confidence in the model, making it more valuable. Nevertheless, it may not always be possible to clearly separate tests of reliability from validity tests because the two concepts are related; low reliability limits the overall validity of a test, and a lack of validity manifests itself in unreliable responses that vary with factors to which they should be robust (Rakotonarivo et al., 2016).

In statistics model validity usually refers to assessing the goodness-of-fit of the model by fitting the model to a sample. Various *numerical* and *graphical* methods are proposed in the literature to assess goodness-of-fit. The most widely used numerical indicator is R^2, a statistic indicating the percentage of total variability in the response variable that is accounted for by the model. Graphical methods include a variety of residual plots from a fitted model which provide information on the adequacy of different aspects of the model. The problem is that the same sample is used twice - to fit the model and to evaluate its performance. Thus, any performance indicator measured on the same sample used to fit the model is biased in favour of the model. The focus of this CONSEED Task 5.2, by contrast, is on evaluating how well the model can predict the probability of the positive event for subjects not included in the original sample on which the model was built. For this purpose, the use of independent data to fit and test the model is preferable (Stevens, 1996; Hosmer and Lemeshow, 2000; Steyerberg et al., 2001; Arboretti & Salmaso, 2003).

There are two main statistical approaches to model validation, namely *external validation* (a new sample of data from the same population - or from a similar population – is used to assess the goodness-of-fit of a previously developed model by applying the model as it is to the new sample) and *internal validation*. Although external validation appears to be a rigorous validation approach, it has certain disadvantages. For instance, the collection of a new sample that will only be used in the validation of the model can be rather costly. Further, even if monetary resources are available, the new sample must be sufficiently representative of the original sample, otherwise the validation process can provide misleading results, either pessimistic or optimistic. For these reasons and due to budget constraints the internal validation approach is adopted in this case.

The most accredited methods for obtaining a good *internal validation* of a model's performance are *data-splitting*, *repeated data-splitting*, *jackknife technique* and *bootstrapping* (Arboretti & Salmaso, 2003). The core concept of these methods is similar: exclude a sub sample of observations, develop a model based on the remaining subjects, and then test the model in the originally excluded subjects. We chose the repeated data splitting approach, for reasons detailed in Arboretti & Salmaso (2003). This implies that the available data is split into two portions. The first portion, called the *fitting sample*, is used to fit the model and the latter, called the *validation sample*, is used to evaluate its performance. The fitting sample can be as large as 75% of the original sample and is extracted from the original sample through a simple random sampling without replacement. Usually, the portion of observations reserved for validation is always less than ½ and in range of ¼ to ⅓ (Harrell et al., 1996). The remaining data is used as a validation sample. That is, the split is purely random and there is no data duplication. A priori we expect a lower performance of the model on the validation sample. Fitting and validation samples in our cases will be defined from original and pooled datasets.

The model validation process of the pooled samples involves the following steps:

(i) Data-splitting

The pooled sample is randomly split into the fitting (70%) and validation samples (30%, to have an adequate number of observations).

(ii) Model fitting

The model is fitted on the fitting sample. The model's coefficients, its overall significance and the partial significance of each variable are estimated.

(iii) Event probability estimation

The fitted model is used to estimate the probability of a positive outcome for each of the subjects in both the fitting and the validation samples. Based on steps (i) to (iii), we derive the following information: the configuration of the covariates X; the observed outcome Y; and the predicted probability of a positive outcome $P(Y = 1|X)$.

(iv) Computation of performance measures

For both the fitting and the validation samples the following statistics are computed:

- C-statistic (measure of predictive power);

- Pearson's χ^2 goodness-of-fit statistic (measure of calibration)

The C-statistic is a measure of goodness of fit for binary outcomes regression models and it is equal to the area under the Receiver Operating Characteristic (ROC) curve and ranges from 0.5 to 1. As a general rule (Hosmer and Lemeshow, 2000):

- if $C \geq 0.9$, the model is considered to have outstanding discrimination
- if $0.8 \leq C < 0.9$, the model is considered to have excellent discrimination
- if $0.7 \leq C < 0.8$, the model is considered to have acceptable discrimination
- if $C = 0.5$, the model has no discrimination

- if C < 0.5, the model has a negative discrimination, i.e. it is worse than random

Pearson's χ^2 goodness-of-fit statistic examines the null hypothesis that the logistic regression model used is the correct model. This statistic has approximately M − k degrees of freedom for the estimation sample, where k is the number of independent variables, including the constant and M is the total number of covariate patterns among the N observations.

(v) Iterations

The above-described procedure is repeated 100 times. Each time the procedure is repeated the sample is split into two random portions, the model is fitted on one of the two portions, and its performance is evaluated on both portions. Since each iteration is based on a different split of the original data, it results in different model coefficients, significance levels, and performance values.

(vi) Results

After the 100 repetitions, the distribution of each of the performance measures is provided for the fitting and validation samples. The *fitting distribution* of a variable is the distribution of that variable computed on the fitting samples, while the *validation distribution* of a variable is computed on the validation samples. As mentioned, in general a reduction in the magnitude of the performance measures of discrimination and calibration is expected. If the drop in the value of the measures is too large, the model does not validate outside the fitting sample. To assess model validity, the equality of the two ROC areas obtained from fitting and validation samples is tested using an algorithm suggested by DeLong, DeLong, and Clarke-Pearson (1988), and the critical values for the Pearson's χ^2 test are examined for the distributions of the 100 repetitions. The distributions of the goodness-of-fit estimates of fitting and the validation samples should be averaged around the same values. If this does not happen, the model cannot be validated because of its internal instability (Arboretti & Salmaso, 2003).

(vii) Evaluation of 'transferability'

After having validated the model for the pooled sample, the same model is fitted to different sub-samples constructed by Country and by Technology, to evaluate the model 'transferability' between countries and technologies using the same performance indicators. In this case, however, the Wald test is also used (Judge et al., 1985) to test the equality of the coefficients across the models. Given that the pooled datasets come from surveys of households and firms, the above-mentioned process is implemented separately for the two groups of interest.

3 Model validation for the household surveys

3.1 Internal validation

The pooled sample included observations from Greece (Appliances), Ireland (Property), Norway (Transport), Slovenia (Property) and Spain (Appliances). In order to validate the pooled sample model, the missing observations were dropped, to correctly compare the curves based on the non-missing data.

The final dataset contained 1,896 observations out of 3,016 (62.8%). Several models were run using diverse sets of predictors, which were initially selected by considering the estimated binary response models reported in Deliverable 3.1. Table 2 presents the marginal effects (at the mean) of the explanatory variables selected on the probability that respondents included in the pooled sample valued EE as a 'Very Important' attribute.

Table 2. Factors influencing energy efficiency valuation for households – probit marginal effects (pooled sample)

VARIABLES	Pooled sample Margins
Attitudes towards EE	
Environmental impact reduction (=1 if strongly disagree)	0.043**
	(0.020)
EE appliances/cars less reliable (=1 if strongly disagree)	-0.056***
	(0.015)
Chance on new technologies (=1 if strongly disagree)	0.081***
	(0.019)
Lack access to loans, etc. (=1 if strongly disagree)	0.030***
	(0.011)
Aware of energy prices (=1 if strongly disagree)	0.053***
	(0.015)
Understand EE cost reduction (=1 if strongly disagree)	0.055***
	(0.016)
Perception on existing label	
Energy labels affect my choices (=1 if strongly disagree)	0.111***
	(0.017)
Environmental awareness	
Concerned about the environment (=1 if not concerned)	0.041***
	(0.015)
Socio-demographics	
Gender (1: Male; 2: Female)	0.106***
	(0.024)
Pseudo-R^2	0.109
Pearson's χ^2	0.106
Observations	1,896

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

According to the model, those who strongly agree that buying a more energy efficient appliance/car/property would reduce the impact of their household compared to those who slightly agree are 4.3% more likely to value EE as a very important attribute, keeping everything else constant. Further, the probability of considering EE as very important attribute is 5.6% lower for those who those who believe that EE appliances/cars/properties are less reliable than those who do not share the same beliefs. Similarly, those who say that they are willing to take a chance on new technologies so as to reduce their energy consumption, are aware of energy prices, understand how much money they would save if they bought a more energy efficient property, and are concerned about the environment have a higher probability of considering EE as a very important attribute than those who believe the opposite (by 8.1%, 5.3%, 5.5% and 4.1%, respectively). Respondents who claim that the lack of access to loans prevents them from making more energy efficient choices also believe that EE is a very important attribute (the probability is 3% higher). Further, women are on average 10.6% more likely to value the EE attribute as very important, compared to men. Finally, and most importantly, the respondents who claim that energy labels would affect their choice are 11% more likely to value the EE attribute as very important.

The pooled model was tested for validity using the process described in Section 2.2. The results for the distribution of each of the performance measures for the fitting and validation samples are summarized in Table 3.

According to ROC comparisons column, the chi-squared test yielded an average significance probability of 0.502, suggesting that there is no significant difference between the two areas of the fitting and validation models. The null hypothesis, i.e. the areas under the ROC curves are equal, is rejected in 9% of the iterations. Thus, it can be argued that the pooled model discriminates very well. The discriminative-ability of the model implies that a randomly selected respondent who believes that EE is very important will have a higher predicted probability of having this outcome occur, compared to a randomly selected respondent who does not believe the same. In other words, it denotes that the model allows us to discriminate between low and high EE importance observations.

Further, as regards the goodness-of-fit of the two models, according to the Pearson's χ^2 results the fitting model is rejected in only 2% of the iterations and the validation model in approximately 5% of the iterations. This is also evident in Figure 1, according of which the models cannot be rejected in almost any iteration.

Table 3. Distribution of performance measures – Household pooled model validation

Parameter	**Values**		
	ROC comparisons prob>χ^2	**Pearson's χ^2 - fitting**	**Pearson's χ^2 - validation**
Mean	0.502	0.169	0.264
Std. Dev.	0.316	0.08	0.141
Percentiles			
1%	0.006	0.043	0.007
5%	0.038	0.062	0.049
10%	0.053	0.077	0.085
25%	0.195	0.106	0.159
50%	0.528	0.160	0.260
75%	0.783	0.214	0.352
90%	0.945	0.26	0.452
95%	0.97	0.343	0.51
99%	0.993	0.402	0.63

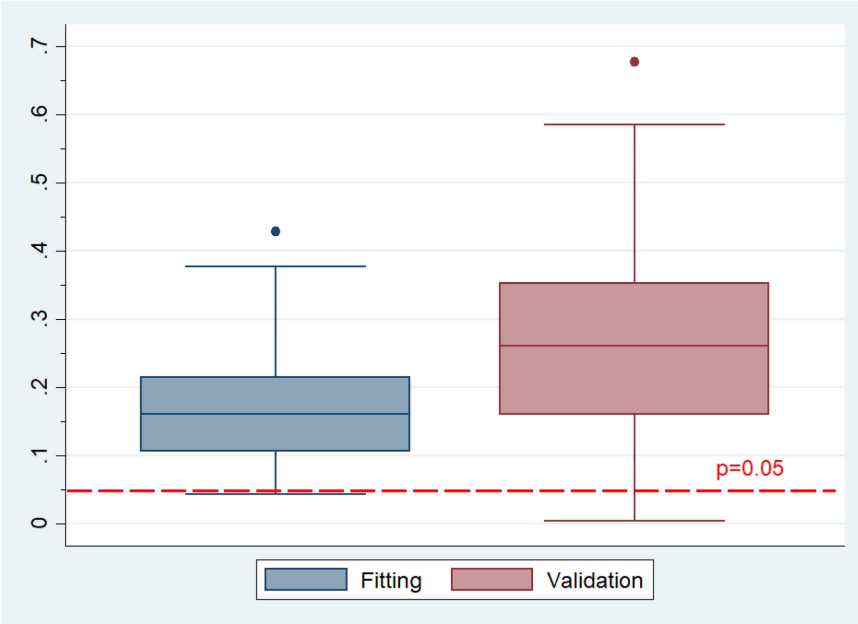


Figure 1. Pearson's χ^2 – Fitting vs. validation model distributions (Households)

3.2 Transferability evaluation

In order to explore the 'transferability' of the pooled model to different countries and technologies (i.e. to examine whether it's possible to create a 'universal' model of EE), eight different models were run for the five countries and three technologies, and the results were compared on the basis of three criteria, i.e. the estimated ROC curve areas, the goodness-of-fit of the models according to the Pearson's χ^2 test and the Wald test regarding the equality of the coefficients.

3.2.1 Country transferability

The results for the five national sub-samples are given in Tables 4 and 5. In general, the calibration criterion is satisfied for all countries (yet, only marginally for the Irish sub-sample). According to ROC comparisons, the chi-squared test yielded an average significance probability of 0.062, suggesting that there is no significant difference between the ROC areas of the five national models.

Table 4. Factors influencing energy efficiency valuation for households – probit marginal effects (Country subsamples)

VARIABLES	Greece Margins	Ireland Margins	Norway Margins	Slovenia Margins	Spain Margins
Attitudes towards EE					
Environmental impact reduction (=1 if strongly disagree)	0.031	0.104*	0.043	0.034	0.072
	(0.041)	(0.056)	(0.032)	(0.047)	(0.053)
EE appliances/cars less reliable (=1 if strongly disagree)	-0.082***	-0.047	-0.014	-0.058	-0.031
	(0.027)	(0.036)	(0.025)	(0.043)	(0.040)
Chance on new technologies (=1 if strongly disagree)	0.070	0.084	0.058*	0.081*	0.092**
	(0.044)	(0.052)	(0.032)	(0.049)	(0.046)
Lack access to loans, etc. (=1 if strongly disagree)	0.024	0.032	0.007	-0.047	-0.027
	(0.026)	(0.035)	(0.021)	(0.032)	(0.030)
Aware of energy prices (=1 if strongly disagree)	0.089***	0.047	0.087**	0.034	0.022
	(0.033)	(0.054)	(0.035)	(0.049)	(0.032)
Understand EE cost reduction (=1 if strongly disagree)	0.005	0.033	0.071**	0.110*	-0.038
	(0.032)	(0.048)	(0.030)	(0.059)	(0.038)
Perception on existing label					
Energy labels affect my choices (=1 if strongly disagree)	0.099***	0.158***	0.055*	0.121**	0.152***
	(0.031)	(0.047)	(0.031)	(0.047)	(0.041)
Environmental awareness					
Concerned about the environment (=1 if not concerned)	0.055**	0.097**	0.014	0.072*	0.023
	(0.027)	(0.048)	(0.026)	(0.039)	(0.038)
Socio-demographics					
Gender (1: Male; 2: Female)	0.073	0.095	0.141***	0.134*	0.061
	(0.046)	(0.069)	(0.044)	(0.071)	(0.052)
Pseudo-R^2	0.143	0.145	0.074	0.124	0.078
Pearson's χ^2 p-values	0.160	0.052	0.414	0.255	0.229
Observations	423	239	582	258	394

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Nevertheless, the C-statistic criterion is fulfilled for three out of the five countries (Table 5 and Figure 2), namely Greece, Ireland and Slovenia. The models for Norway and Spain, although marginally, do not to present acceptable discrimination.

Table 5. Comparison of the ROC areas - Country subsamples models (Households)

Country	Obs.	ROC Area	Std. Err.	Asymptotic Normal [95% Conf. Interval]	
Greece	423	0.751	0.025	0.701	0.800
Ireland	239	0.766	0.031	0.705	0.827
Norway	582	0.679	0.022	0.635	0.722
Slovenia	258	0.736	0.031	0.675	0.797
Spain	394	0.686	0.028	0.631	0.740

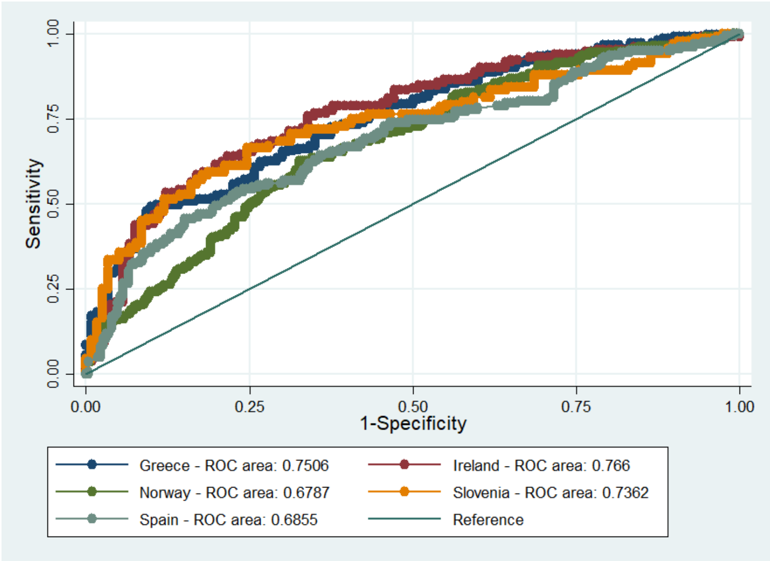


Figure 2. ROC curves and C-statistic estimates for the national models (Households)

Since the value and the statistical significance of the coefficients across the pooled and the national sub-models differ, the Wald test was implemented to test whether this difference is statistically significant. The results are given in Table 6. The null hypothesis that all the coefficients in the examined models are equal is rejected between the pooled model and the models for Spain and Norway, as well as between the models for Spain and Norway. These results are consistent with the remarks made about the discrimination of these two models. All in all, it could be argued that the model is not transferable across all countries mainly because the importance of EE varied between the samples as reported in Deliverable 3.1.

Table 6. Wald test results for the pooled and national subsamples models (Households)

Country difference	**Prob > χ^2**	**Country difference**	**Prob > χ^2**
Pooled-Greece	0.6309	Greece- Spain	0.3868
Pooled-Ireland	0.8729	Ireland-Norway	0.2851
Pooled-Norway	0.0008	Ireland-Slovenia	0.8248
Pooled-Slovenia	0.4483	Ireland-Spain	0.7184
Pooled-Spain	0.0137	Norway-Slovenia	0.6733
Greece- Ireland	0.9371	Norway-Spain	0.0298
Greece- Norway	0.1386	Slovenia-Spain	0.4350
Greece- Slovenia	0.7912		

3.2.2 Technology transferability

The results for the technological sub-samples are presented in Tables 7 and 8. The null hypothesis that the regression model used is the correct model cannot be rejected at 5% level (it is rejected at 10% level for the Properties model). Based on the Pearson's χ^2 test, it is suggested that there is a significant difference between the ROC areas of the three models (p = 0.034). The test is rejected due to the Transport model, which has also unacceptable discrimination given that the C-statistic is below 0.7 (Table 8 and Figure 3).

Finally, the 'transferability' of the model was examined by means of the Wald test, the results of which are summarised in Table 9. The null hypothesis that all the coefficients in the examined models are equal is rejected between the pooled model and the Transport model, and between the Transport model and the Appliances model. Again, the Wald test results coincide with the results of discrimination for the Transport model. Overall, it could be argued that the model is transferable as regards the Appliances and Properties, but not for the Transport model.

Table 7. Factors influencing energy efficiency valuation for households – probit marginal effects (Technology subsamples)

VARIABLES	Appliances Margins	Properties Margins	Transport Margins
Environmental impact reduction (=1 if strongly disagree)	0.040	0.059*	0.043
	(0.036)	(0.035)	(0.032)
EE appliances/cars less reliable (=1 if strongly disagree)	-0.079***	-0.059**	-0.014
	(0.025)	(0.027)	(0.025)
Chance on new technologies (=1 if strongly disagree)	0.117***	0.086**	0.058*
	(0.034)	(0.035)	(0.032)
Lack access to loans, etc. (=1 if strongly disagree)	0.050***	-0.012	0.007
	(0.019)	(0.023)	(0.021)
Aware of energy prices (=1 if strongly disagree)	0.081***	0.026	0.087**
	(0.024)	(0.035)	(0.035)
Understand EE cost reduction (=1 if strongly disagree)	0.020	0.072**	0.071**
	(0.026)	(0.035)	(0.030)
Energy labels affect my choices (=1 if strongly disagree)	0.142***	0.130***	0.055*
	(0.027)	(0.032)	(0.031)
Concerned about the environment (=1 if not concerned)	0.044*	0.076***	0.014
	(0.024)	(0.029)	(0.026)
Gender (1: Male; 2: Female)	0.065*	0.121**	0.141***
	(0.037)	(0.049)	(0.044)
Pseudo-R^2	0.143	0.124	0.074
Pearson's χ^2	0.179	0.093	0.414
Observations	817	497	582

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Comparison of the ROC areas - Technology subsamples models (Households)

Technology	Obs	ROC Area	Std. Err.	Asymptotic Normal [95% Conf. Interval]	
Appliances	817	0.747	0.017	0.714	0.78
Properties	497	0.745	0.022	0.701	0.788
Transport	582	0.679	0.022	0.635	0.722

Table 9. Wald test results for the pooled and technological subsamples models (Households)

Country difference	Prob > χ^2
Pooled-Appliances	0.1284
Pooled-Properties	0.4709
Pooled-Transport	0.0008
Appliances-Properties	0.4161
Appliances-Transport	0.0171
Properties- Transport	0.1954

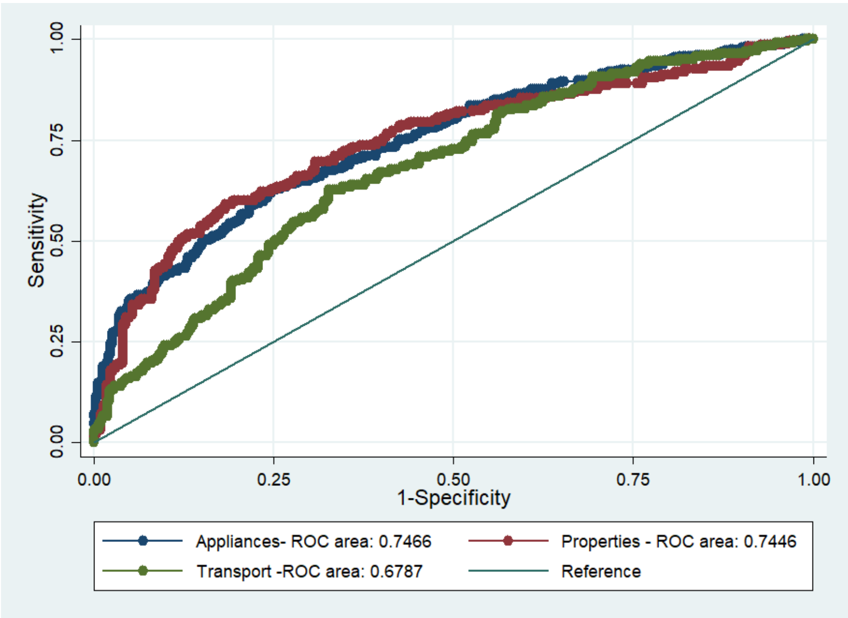


Figure 3. ROC curves and C-statistic estimates for the technological models (Households)

4 Model validation for the firm surveys

4.1 Internal validation

The pooled sample for the firms included observations from Greece (Appliances in Services sector), Spain (Appliances in Services sector) and Ireland (Properties and Services sector and Machinery in Agricultural sector). The missing observations were dropped from the dataset prior validating the pooled sample model in order to correctly compare the ROC curves. The final dataset contained 555 observations out of 794 (70%). Several models were run using diverse sets of predictors, which were initially selected by considering the estimated binary response models reported in Deliverable 3.1.

Table 10 presents the marginal effect of the explanatory variables selected on the probability that respondents included in the pooled sample valued EE as a 'Very Important' attribute.

According to the model, the marginal effect at the means (MEM) for those who strongly agree that buying more energy efficient equipment would reduce the environmental impact of their business is 6.7% (i.e. on average they are about 7% more likely to value EE as a very important attribute). The MEMs for those who say that are willing to take a chance on new technologies so as to reduce their energy consumption and understand how much money they would save if they bought a more energy efficient property are 7.8% and 10.0% more likely to rate EE as a very important attribute, respectively. Further, respondents who claim that the lack of access to loans prevents them from making more energy efficient choices also believe that EE is a very important attribute (MEM: 4.6%). Finally, interviewees who claim that energy labels would affect their choice are 4.7% more likely to value the EE attribute as very important.

Table 10. Factors influencing energy efficiency valuation for firms – probit marginal effects (pooled sample)

VARIABLES	**Pooled sample Margins**
Attitudes towards EE	
Environmental impact reduction (=1 if strongly disagree)	0.067**
	(0.028)
Chance on new technologies (=1 if strongly disagree)	0.078***
	(0.030)
Lack access to loans, etc. (=1 if strongly disagree)	0.046**
	(0.019)
Understand EE cost reduction (=1 if strongly disagree)	0.100***
	(0.025)
Perception on existing label	
Energy labels affect my choices (=1 if strongly disagree)	0.047*
	(0.026)
Pseudo-R^2	0.085
Pearson's χ^2	0.536
Observations	555

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The pooled model was tested for validity using the process described in Section 2.2. The results for the distribution of each of the performance measures for the fitting and validation samples are summarized in Table 11.

Based on the ROC comparisons results, the chi-squared test yielded an average significance probability of 0.565, which suggests that there is no statistically significant difference between the fitting and validation models ROC areas. The null hypothesis, i.e. the areas under the ROC curves are equal, is rejected in 3% of the iterations. Thus, it can be argued that the model discriminates very well.

With regards to the goodness-of-fit of the two models, according to the Pearson's χ^2 results the fitting model is not rejected in any of the iterations and the validation model is rejected in 2% of the iterations. Further, as illustrated in Figure 4, the models cannot be rejected practically in any of the iterations.

Table 11. Distribution of performance measures – Firms pooled model validation

Parameter	**Values**		
	ROC comparisons prob>χ^2	**Pearson's χ^2 - fitting**	**Pearson's χ^2 - validation**
Mean	0.565	0.491	0.364
Std. Dev.	0.264	0.166	0.188
Percentiles			
1%	0.002	0.123	0.015
5%	0.093	0.222	0.078
10%	0.151	0.266	0.115
25%	0.367	0.363	0.225
50%	0.612	0.506	0.345
75%	0.782	0.626	0.510
90%	0.913	0.683	0.639
95%	0.959	0.763	0.685
99%	0.976	0.804	0.724

Figure 4. Pearson's χ^2 – Fitting vs. validation model distributions

4.2 Transferability evaluation

The 'transferability' of the firms' pooled model was also tested for different countries and technologies, just like in the case of the households' pooled model. In total, eight different models were run for the three countries, three technologies, and two sectors, which were compared using the three criteria, i.e. the estimated area of ROC curves, the goodness-of-fit of the models according to the Pearson's χ^2 test and the Wald test regarding the equality of the coefficients.

4.2.1 Country transferability

The results for the three national sub-samples are given in Tables 12 and 13. The calibration criterion is generally satisfied for all countries. As far as the C-statistic criterion is concerned, however, none of the models present acceptable discrimination (Table 5 and Figure 2). Especially in Greece, the ROC curve area indicates a model which has a negative discrimination, i.e. it is worse than random.

Table 12. Factors influencing energy efficiency valuation for firms – probit marginal effects (Country subsamples)

VARIABLES	Greece Margins	Ireland Margins	Spain Margins
Attitudes towards EE			
Environmental impact reduction (=1 if strongly disagree)	-	0.056*	0.026
		(0.029)	(0.084)
Chance on new technologies (=1 if strongly disagree)	-	0.038	0.124
		(0.032)	(0.083)
Lack access to loans, etc. (=1 if strongly disagree)	0.012	0.015	0.005
	(0.040)	(0.022)	(0.062)
Understand EE cost reduction (=1 if strongly disagree)	0.026	0.119***	-0.027
	(0.059)	(0.029)	(0.074)
Perception on existing label	-		
Energy labels affect my choices (=1 if strongly disagree)	-	0.024	-0.001
		(0.029)	(0.097)
Pseudo-R^2	0.012	0.057	0.027
Pearson's χ^2	0.156	0.659	0.536
Observations	47	409	82

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 13. Comparison of the ROC areas - Country subsamples models (Firms)

Country	Obs.	ROC Area	Std. Err.	Asymptotic Normal [95% Conf. Interval]	
Greece	64	0.386	0.101	0.189	0.583
Ireland	409	0.659	0.027	0.607	0.712
Spain	82	0.640	0.063	0.516	0.764

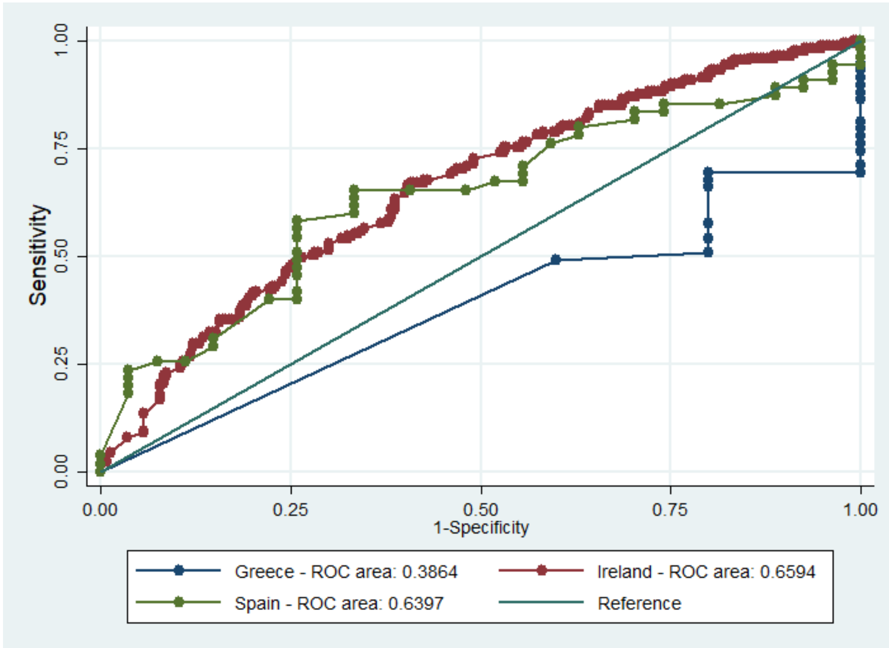


Figure 5. ROC curves and C-statistic estimates for the national models (Firms)

Since the national models failed to provide an adequate discrimination no further tests were carried out. All in all, it could be argued that the model is not transferable across countries. However, this conclusion should be seen with caution owing to the small number of observations in the cases of Spain and Greece.

4.2.2 Technology transferability

The results for the three technological sub-samples are given in Tables 14 and 15. The calibration criterion is generally satisfied for all countries, therefore the null hypothesis that the logistic regression model used is the correct model cannot be rejected at 5% level. Based on the Pearson's χ^2 test, it is suggested that there is no difference between the ROC areas of the three models ($p = 0.729$) (Table 15 and Figure 6). However, for the Appliances model the predictive power is barely acceptable.

Although the discrimination of the models is not satisfactory, the 'transferability' of the model was examined by means of the Wald test (Table 16). The null hypothesis is rejected between the pooled model and the Transport model, just like in the household survey. Therefore, it could be argued that the model is transferable as regards the Appliances and Properties, but not for the Transport. Yet, as mentioned, the models have weak predictive power.

Table 14. Factors influencing energy efficiency valuation for firms – probit marginal effects (Technology subsamples)

VARIABLES	Appliances Margins	Properties Margins	Transport Margins
Attitudes towards EE			
Environmental impact reduction (=1 if strongly disagree)	0.035	0.053	0.026
	(0.063)	(0.043)	(0.084)
Chance on new technologies (=1 if strongly disagree)	0.115*	0.015	0.124
	(0.061)	(0.048)	(0.083)
Lack access to loans, etc. (=1 if strongly disagree)	0.007	0.046	0.005
	(0.034)	(0.034)	(0.062)
Understand EE cost reduction (=1 if strongly disagree)	0.060	0.010	-0.027
	(0.040)	(0.039)	(0.074)
Perception on existing label			
Energy labels affect my choices (=1 if strongly disagree)	-0.039	0.083*	-0.001
	(0.057)	(0.049)	(0.097)
Pseudo-R^2	0.074	0.064	0.048
Pearson's χ^2	0.176	0.403	0.517
Observations	146	144	265

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 15. Comparison of the ROC areas - Technology subsamples models (Firms)

Technology	Obs.	ROC Area	Std. Err.	Asymptotic Normal [95% Conf. Interval]	
Appliances	146	0.703	0.055	0.595	0.811
Properties	144	0.682	0.050	0.583	0.780
Transport	265	0.654	0.034	0.588	0.720

Table 16. Wald test results for the pooled and technological subsamples models (Firms)

Country difference	Prob > χ^2
Pooled-Appliances	0.5020
Pooled-Properties	0. 2330
Pooled-Transport	0. 0057
Appliances-Properties	0. 2614
Appliances-Transport	0. 9300
Properties- Transport	0. 1460

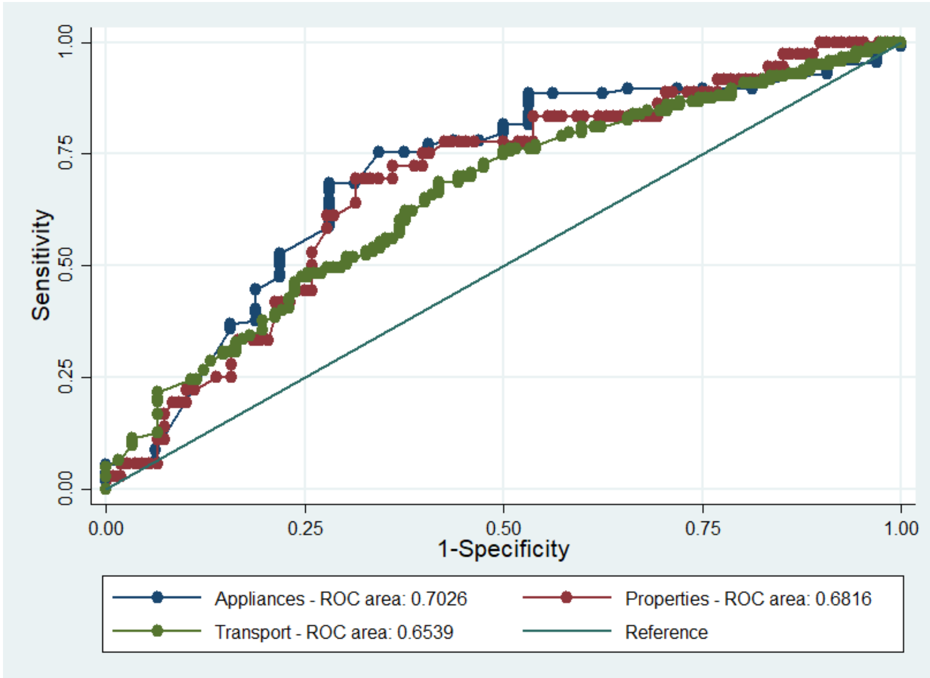


Figure 6. ROC curves and C-statistic estimates for the technological models (Firms)

4.2.3 Sector transferability

Finally, the 'transferability' of the model was tested using the sectoral sub-samples (i.e. agriculture and services). The results are presented in Tables 17 and 18. The calibration criterion is satisfied for both sectoral models, (i.e. the hypothesis that the correct model is used cannot be rejected). Based on the Pearson's χ^2 test, the null hypothesis that there is no difference between the ROC areas of the two models is rejected (p = 0.015). Further, only the Services model shows an acceptable C-statistic value (Table 18 and Figure 7).

Finally, the 'transferability' of the model was examined by means of the Wald test (Table 19). The null hypothesis is rejected for all pair comparisons. Therefore, it can be concluded that the model is not transferable across sectors.

Table 17. Factors influencing energy efficiency valuation for firms – probit marginal effects (Sectoral subsamples)

VARIABLES	Agriculture Margins	Services Margins
Attitudes towards EE		
Environmental impact reduction (=1 if strongly disagree)	0.037	0.095**
	(0.037)	(0.044)
Chance on new technologies (=1 if strongly disagree)	0.066	0.096**
	(0.040)	(0.048)
Lack access to loans, etc. (=1 if strongly disagree)	-0.016	0.099***
	(0.027)	(0.028)
Understand EE cost reduction (=1 if strongly disagree)	0.118***	0.075**
	(0.042)	(0.035)
Perception on existing label		
Energy labels affect my choices (=1 if strongly disagree)	-0.005	0.089**
	(0.036)	(0.043)
Pseudo-R^2	0.048	0.162
Pearson's χ^2	0.517	0.453
Observations	265	290

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 18. Comparison of the ROC areas - Sectoral subsamples models (Firms)

Technology	Obs	ROC Area	Std. Err.	Asymptotic Normal [95% Conf. Interval]	
Agriculture	265	0.654	0.034	0.588	0.720
Services	290	0.760	0.028	0.706	0.815

Table 19. Wald test results for the pooled and sectoral subsamples models (Firms)

Technology difference	Prob > χ^2
Pooled-Agriculture	0. 0057
Pooled-Services	0. 0125
Agriculture-Services	0. 0040

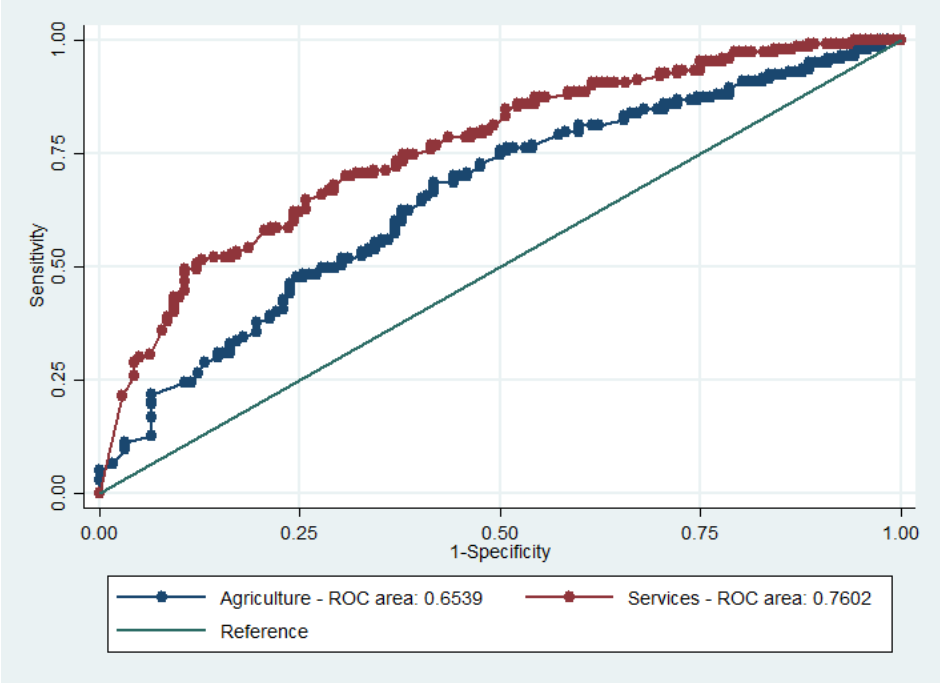


Figure 7. ROC curves and C-statistic estimates for the sectoral models (Firms)

5 Conclusions

The aim of this deliverable is to apply state-of-the-art econometric techniques in validating the theoretical and econometric models developed in Deliverable 3.1. The CONSEED partners designed the surveys, discrete choice experiments and field trials in a harmonized way to facilitate subsequent data pooling where possible which provided two homogenized datasets for validation purposes.

The main conclusions drawn from the validation process, are as follows:

- According to C-statistic, which provides a measure of the predictive power of the model, and Pearson's χ^2 goodness-of-fit statistic, which offers a measure of calibration of the model, **i.e. the regression model used in CONSEED is the correct one, the pooled models derived for the households and the firm samples pass the internal validation tests.** Further, given the larger number of observations and the diverse nature of population, the pooled samples seem to allow for a more reliable investigation of the relative importance of the factors influencing consumers' attitudes and beliefs towards energy investment decisions.
- CONSEED results (Deliverable 3.1) indicate that EE importance varied across products and across countries i.e. consumers in different countries value energy efficiency differently. For instance, in household appliance EE was among the top two factors (more than 70% rate is as very important), while for cars EE was ranked only fourth. For this reason, we expect that transferability of results (i.e. the use of a 'universal' model of EE from the pooled model), across

countries is limited and this is confirmed in the statistical tests used to determine transferability in this deliverable. Similarly, relatively small sample sizes for some sectors contributes to low transferability.

All in all, although pooled models are validated, the extrapolation of the results to specific populations in terms of 'space' (i.e. country) and 'target' (e.g. sectors and technologies) should be seen with caution from a policy perspective. Towards providing more consistent answers, future research surveys need to collect different sub-samples for each country and for a number of products that will allow international and intersectoral comparisons.

6 References

Arboretti, R., & Salmaso, L. (2003). Model performance analysis and model validation in logistic regression. Statistica, 63(2), 375–396.

DeLong, E. R., D. M. DeLong, and D. L. Clarke-Pearson (1988). Comparing the areas under two or more correlated receiver operating characteristic curves: A nonparametric approach. Biometrics, 44, 837–845.

Harrell, F. E., Lee, K. L., & Mark, D. B. (1996). Multivariable prognostic models: Issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors. Statistics in Medicine, 15(4), 361–387.

Hosmer, D.W. and Lemeshow, S. (2000). Applied Logistic Regression, 2nd edition. John Wiley & Sons, Inc., New York.

John O. P., Benet-Martinez V. (2014). Measurement: reliability, construction validation, and scale construction, in Handbook of Research Methods in Social and Personality Psychology, eds Reis H. T., Judd C. M., editors. (New York, NY: Cambridge University Press), 473–503.

Judge, G.G., Griffiths, W.E., Hill, R.C., Lutkepohl, H., and Lee, T.-C. (1985). The Theory and Practice of Econometrics. 2nd ed.. New York: Wiley.

Rakotonarivo, O. S., Schaafsma, M., & Hockley, N. (2016, December 1). A systematic review of the reliability and validity of discrete choice experiments in valuing non-market environmental goods. Journal of Environmental Management, 183, 98-109.

Stevens, J. (1996). Applied multivariate statistics for the social sciences, third edition, Lawrence Erlbaum Associates, Mahwan, New Jersey.

Steyerberg, E. W., Harrell, F. E., Borsboom, G. J. J. M., Eijkemans, M. J. C., Vergouwe, Y., & Habbema, J. D. F. (2001). Internal validation of predictive models: Efficiency of some procedures for logistic regression analysis. Journal of Clinical Epidemiology, 54(8), 774–781.

7 Appendices

Appendix I: Indicative list of common questions in household surveys

Section	Variable Coding	Question/Label
Attitudes	**Q7**	IRELAND FORMAT: Buying a more energy efficient property would reduce my household's environmental impact
Attitudes	**Q7**	GREECE FORMAT: Buying a more energy efficient refrigerator would reduce my household's environmental impact
Attitudes	**Q7**	SPAIN FORMAT: Buying a more energy efficient washing machine would reduce my household's environmental impact
Attitudes	**Q7**	SLOVENIA FORMAT: Buying a more energy efficient property would reduce my household's environmental impact
Attitudes	**Q7**	NORWAY FORMAT: Buying a more energy efficient car would reduce my household's environmental impact
Attitudes	**Q8**	IRELAND FORMAT: All new properties have similar energy efficiency levels
Attitudes	**Q8**	GREECE FORMAT: All new refrigerators have similar energy efficiency levels
Attitudes	**Q8**	SPAIN FORMAT: All new washing machines have similar energy efficiency levels
Attitudes	**Q8**	SLOVENIA FORMAT: All new properties have similar energy efficiency levels
Attitudes	**Q8**	NORWAY FORMAT: All new cars have similar energy efficiency levels
Attitudes	**Q9**	IRELAND FORMAT: More energy efficient appliances are less reliable
Attitudes	**Q9**	GREECE FORMAT: More energy efficient refrigerators are less reliable
Attitudes	**Q9**	SPAIN FORMAT: More energy efficient washing machines are less reliable
Attitudes	**Q9**	SLOVENIA FORMAT: More energy efficient appliances are less reliable
Attitudes	**Q9**	NORWAY FORMAT: More energy efficient cars (electric vehicles and plug-in hybrids) are less reliable
Attitudes	**Q11**	IRELAND FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attitudes	**Q11**	GREECE FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attitudes	**Q11**	SPAIN FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attitudes	**Q11**	SLOVENIA FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attitudes	**Q11**	NORWAY FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attitudes	**Q12**	IRELAND FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices
Attitudes	**Q12**	GREECE FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices
Attitudes	**Q12**	SPAIN FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices
Attitudes	**Q12**	SLOVENIA FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices
Attitudes	**Q12**	NORWAY FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices
Attitudes	**Q13**	IRELAND FORMAT: I have a good understanding of my property's energy consumption
Attitudes	**Q13**	GREECE FORMAT: I have a good understanding of my refrigerator's energy consumption
Attitudes	**Q13**	SPAIN FORMAT: I have a good understanding of my washing machine's energy consumption
Attitudes	**Q13**	SLOVENIA FORMAT: I have a good understanding of my property's energy consumption
Attitudes	**Q13**	NORWAY FORMAT: I have a good understanding of my car's energy consumption
Attitudes	**Q14**	IRELAND FORMAT: I am aware of energy prices, that is the price of fuels such as gas, oil and electricity
Attitudes	**Q14**	GREECE FORMAT: I am aware of electricity energy prices
Attitudes	**Q14**	SPAIN FORMAT: I am aware of the price of the kwh
Attitudes	**Q14**	SLOVENIA FORMAT: I am aware of energy prices, that is the price of fuels such as gas, oil and electricity
Attitudes	**Q14**	NORWAY FORMAT: I am aware of energy prices, that is the price of fuel and electricity
Attitudes	**Q15**	IRELAND FORMAT: I understand how much money I would save if I bought a more energy efficient property
Attitudes	**Q15**	GREECE FORMAT: I understand how much money I would save if I bought a more energy efficient refrigerator
Attitudes	**Q15**	SPAIN FORMAT: I understand how much money I would save if I bought a more energy efficient washing machine
Attitudes	**Q15**	SLOVENIA FORMAT: I understand how much money I would save if I bought a more energy efficient property

Attitudes	**Q15**	NORWAY FORMAT: I understand how much money I would save if I bought a more energy efficient car
Attitudes	**Q16**	IRELAND FORMAT: I would be more likely to upgrade the energy efficiency of my property (for example, improving windows, insulation and heating system) if my friends, neighbours or colleagues also do so
Attitudes	**Q16**	GREECE FORMAT: I would be more likely to buy an energy efficient refrigerator if my friends, neighbours or colleagues also do so
Attitudes	**Q16**	SPAIN FORMAT: I would be more likely to buy an energy efficient washing machine if my friends, neighbours or colleagues also do so
Attitudes	**Q16**	SLOVENIA FORMAT: I would be more likely to upgrade the energy efficiency of my property (for example, improving windows, insulation and heating system) if my friends, neighbours or colleagues also do so
Attitudes	**Q16**	NORWAY FORMAT: I would be more likely to upgrade the energy efficiency of my car (for example, improving windows, insulation and heating system) if my friends, neighbours or colleagues also do so
Attitudes	**Q17**	IRELAND FORMAT: I cannot afford to upgrade the energy efficiency of my home
Attitudes	**Q17**	GREECE FORMAT: I cannot afford to buy an energy efficient refrigerator
Attitudes	**Q17**	SPAIN FORMAT: I cannot afford to upgrade the energy efficiency of my washing machine
Attitudes	**Q17**	SLOVENIA FORMAT: I cannot afford to upgrade the energy efficiency of my home
Attitudes	**Q17**	NORWAY FORMAT: NA
Section	**Variable Coding**	**Question/Label**
Labelling	**Q18**	IRELAND FORMAT: Are you aware with the Building Energy Rating (BER) certificate scheme?
Labelling	**Q18**	GREECE FORMAT: Are you aware with the Energy Label?
Labelling	**Q18**	SPAIN FORMAT: Are you aware with the Energy Label for Appliances?
Labelling	**Q18**	SLOVENIA FORMAT: Are you familiar with the *Building Energy Rating* (BER) certificate scheme?
Labelling	**Q18**	NORWAY: Are you aware of the *environment and energy labels for new cars?*
Labelling	**Q19**	IRELAND FORMAT: [if Q18=”Yes”] Did the BER affect the choice of your current property?
Labelling	**Q19**	GREECE FORMAT: Did the Energy Label affect the choice of your current refrigerator?
Labelling	**Q19**	SPAIN FORMAT: [if Q18=”Yes”]Did the Energy Label affect the choice of your washing machine?
Labelling	**Q19**	SLOVENIA FORMAT: [if Q18=”Yes”] Did the BER affect the choice of your current property?
Labelling	**Q19**	NORWAY: [if Q18=”Yes”] Did the environment and energy label affect the choice of your car?
Labelling	**Q20**	IRELAND FORMAT: [if Q18=”Yes”] What is the BER of your current property?
Labelling	**Q20**	GREECE FORMAT: What is the energy class of your current refrigerator
Labelling	**Q20**	SPAIN FORMAT: [if Q18=”Yes”]What is the energy efficiency grade of your washing machine?
Labelling	**Q20**	SLOVENIA FORMAT: [if Q18=”Yes”] What is the BER of your current property?
Labelling	**Q20**	NORWAY: [if Q18=”Yes”] What is the CO2 category of your current car?
Section	**Variable Coding**	**Question/Label**
Environmental	**Q37**	Please rate how concerned you are about the environment (for example, pollution, global warming and climate change)
Section	**Variable Coding**	**Question/Label**
Demographics	**C1**	What age are you?
Demographics	**C2**	What is you gender?
Demographics	**C3**	Which of the following best describes your living situation?

Appendix II: Indicative list of common questions in firms surveys

Section	Variable Coding	Question/Label
Attitudes	**Q7**	IRELAND SERVICES FORMAT: Buying a more energy efficient property would reduce my business's environmental impact
Attitudes	**Q8**	IRELAND SERVICES FORMAT: All new properties have similar energy efficiency levels
Attitudes	**Q9**	IRELAND SERVICES FORMAT: More energy efficient appliances are less reliable
Attitudes	**Q11**	IRELAND SERVICES FORMAT: My business is willing to take a chance on new technologies to reduce our energy consumption
Attitudes	**Q12**	IRELAND SERVICES FORMAT: Lack of access to loans (excluding loans from friends and family) prevents my business from making more energy efficient choices
Attitudes	**Q13**	IRELAND SERVICES FORMAT: I have a good understanding of my property's energy consumption
Attitudes	**Q14**	IRELAND SERVICES FORMAT: I am aware of energy prices, that is the price of fuels such as gas, oil and electricity
Attitudes	**Q15**	IRELAND SERVICES FORMAT: I understand how much money my business would save if I bought or leased a more energy efficient property
Attitudes	**Q16**	IRELAND SERVICES FORMAT: I would be more likely to upgrade the energy efficiency of my property (for example, improving windows, insulation and heating system) if other businesses did so also
Attitudes	**Q17**	IRELAND SERVICES FORMAT: I cannot afford to upgrade the energy efficiency of my property
Attributes	**Q7**	IRELAND AGRICULTURE FORMAT: Buying a more fuel efficient tractor would reduce my farm's environmental impact
Attributes	**Q8**	IRELAND AGRICULTURE FORMAT: All new tractors have similar fuel efficiency levels
Attributes	**Q9**	IRELAND AGRICULTURE FORMAT: More fuel efficient tractors are less reliable
Attributes	**Q11**	IRELAND AGRICULTURE FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attributes	**Q12**	IRELAND AGRICULTURE FORMAT: My lack of access to loans (excluding loans from friends and family) prevents me from making more energy efficient choices on the farm
Attributes	**Q13**	IRELAND AGRICULTURE FORMAT: I have a good understanding of my tractor's fuel consumption
Attributes	**Q14**	IRELAND AGRICULTURE FORMAT: I am aware of energy prices, that is the price of diesel and electricity
Attributes	**Q15**	IRELAND AGRICULTURE FORMAT: I understand how much money I would save if I bought a more fuel efficient tractor
Attributes	**Q16**	IRELAND AGRICULTURE FORMAT: I would be more likely to buy more fuel efficient tractors if other farmers did so too
Attributes	**Q17**	IRELAND AGRICULTURE FORMAT: I cannot afford more fuel efficient tractors
Attributes	**Q7**	SPAIN SERVICES FORMAT: Buying a more energy efficient heating and cooling system would reduce my lodging's environmental impact
Attributes	**Q8**	SPAIN SERVICES FORMAT: All new heating and cooling systems have similar energy efficiency levels
Attributes	**Q9**	SPAIN SERVICES FORMAT: More energy efficient heating and cooling systems are less reliable
Attributes	**Q11**	SPAIN SERVICES FORMAT: I am willing to take a chance on new technologies to reduce my lodging's energy consumption
Attributes	**Q12**	SPAIN SERVICES FORMAT: Lack of access to loans (excluding loans from friends and family) prevents us from making more energy efficient choices
Attributes	**Q13**	SPAIN SERVICES FORMAT: I have a good understanding of heating and cooling system's energy consumption in the lodging
Attributes	**Q14**	SPAIN SERVICES FORMAT: I am aware of energy prices, that is the price of energy sources (gas, oil, electricity) that our lodging uses
Attributes	**Q15**	SPAIN SERVICES FORMAT: I understand how much money I would save if my lodging bought a more energy efficient heating and cooling system
Attributes	**Q16**	SPAIN SERVICES FORMAT: My lodging would be more likely to buy an energy efficient heating and cooling system if other lodgings also do so
Attributes	**Q17**	SPAIN SERVICES FORMAT: My lodging cannot afford to upgrade the energy efficiency of our heating and cooling system
Attributes	**Q7**	GREECE SERVICES FORMAT: Buying a more energy efficient system would reduce my unit's environmental impact

Attributes	**Q8**	GREECE SERVICES FORMAT: All new systems have similar energy efficiency levels
Attributes	**Q9**	GREECE SERVICES FORMAT: More energy efficient systems are less reliable
Attributes	**Q11**	GREECE SERVICES FORMAT: I am willing to take a chance on new technologies to reduce my energy consumption
Attributes	**Q12**	GREECE SERVICES FORMAT: Lack of financial incentives prevents me from making more energy efficient choices
Attributes	**Q13**	GREECE SERVICES FORMAT: I have a good understanding of my system's energy consumption
Attributes	**Q14**	GREECE SERVICES FORMAT: I am aware of electricity energy prices
Attributes	**Q15**	GREECE SERVICES FORMAT: I understand how much money I would save if I bought a more energy efficient system
Attributes	**Q16**	GREECE SERVICES FORMAT: I would be more likely to buy an energy efficient refrigerator if my peers do so
Attributes	**Q17**	GREECE SERVICES FORMAT: I cannot afford to buy an energy efficient system
Section	**Variable Coding**	**Question/Label**
Labelling	**Q18**	Are you aware of the [*INSERT LABELLING SCHEME*] for [*INSERT TECHNOLOGY*]
Labelling	**Q19**	[if Q18="Yes"] Did the [*INSERT LABELLING SCHEME*] affect the choice of [*INSERT TECHNOLOGY*]?
Labelling	**Q20**	[if Q18="Yes"] What is the ratings of your [*INSERT TECHNOLOGY*]?
Labelling	**Q21**	It is understandable
Labelling	**Q22**	It is trustworthy
Labelling	**Q25**	It is manipulated by sellers
Labelling	**Q26**	It would affect which [*INSERT TECHNOLOGY*] I choose
Labelling	**Q27**	It helps me to understand how much energy a [*INSERT TECHNOLOGY*] uses
Labelling	**Q28**	It helps me calculate how much a [*INSERT TECHNOLOGY*] will cost to run
Section	**Variable Coding**	**Question/Label**
Environmental	**Q37**	Please rate how concerned you are about the environment (for example, pollution, global warming and climate change)