CONSumer Energy Efficiency Decision making

REPORT ON IMPLICIT DISCOUNT RATES FOR ENERGY INVESTMENT DECISIONS

June 30, 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 5.2
Title	Report on implicit discount rates for energy investment decisions
Dissemination Level	Public
Date	June 30, 2019 (M31)
Nature	Report
Authors	Sébastien Foudi (BC3), Ibon Galarraga (BC3), Mari Mar Sola (BC3) James Carroll (TCD), Eleanor Denny (TCD) Dimitris Damigos (AUA), Michalis Skourtos (AUA), Areti Kontogianni, (AUA) Steffen Kallbekken (CICERO), Håkon Sælen (CICERO) Edin Lakić (UL), Andrej Gubina (UL)
Contributors	
Reviewers	

Document History

Date	Action	Status
15/03/2019	Partners send their contribution in the template	completed
22/03/2019	BC3 sends the draft V1 to start the reviews process	Completed
28/03/2019	CICERO review	Completed
01/04/2019	AUA review	Completed
03/04/2019	UL review	Completed
04/04/2019	TCD review	Completed

12/06/2019	BC3 prepares the V2 version	Completed
12/06/2019	TCD review	Completed
14/06/2019	AUA review	Completed
17/06/2019	CICERO review	Completed
18/06/2019	UL review	Completed
25/06/2019	BC3 final version	Completed
30/06/2019	Deliverable submission	Completed

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.

Table of Contents

Executive summary

The **implicit or individual discount rate (IDR)** measures how much consumers discount the future and are willing to take into account the future operating costs or energy savings associated with their purchases. This discount rate is a central element of the **energy efficient gap** as indicated by the literature review conducted in CONSEED Deliverable 1. Positive and high discount rates mean consumers are applying a high discount on future operating costs or energy savings, i.e. they tend to value the benefits in the near term more than the benefits in the future. Low discount rates mean they are more likely to consider those costs or savings in their purchase and are likely to buy energy efficient (EE) technologies. A negative discount rate can be found when consumers are willing to buy EE goods even if expected financial savings are less than the investment cost if we consider only the direct financial benefits. Motives for such behaviours can be related to altruistic behaviours or coverage against price variability.

This deliverable proposes an **estimation of the IDR for different products and sectors in different countries, using different methods:** (i) a direct question asking consumers the amount of savings that would make them buy a more EE product, (ii) discrete choice experiments (DCE) presenting hypothetical choice cards with different attributes in addition to the EE attributes, (iii) field trials (FT) with real purchases. These experimental methods (ii and iii) facilitated testing the effect of displaying monetary information on the IDR. Three main messages can be taken from the analysis.

The individual discount rate is driven by the product considered, not necessarily by the country where it is estimated. Product differences are highlighted in Figure 1. The median IDR varies from 6% for cars in Norway to 31% for a refrigerator in Greece in the household sector. It varies from 21% for a tractor device in Ireland to 31% for heating and cooling system in Greece.

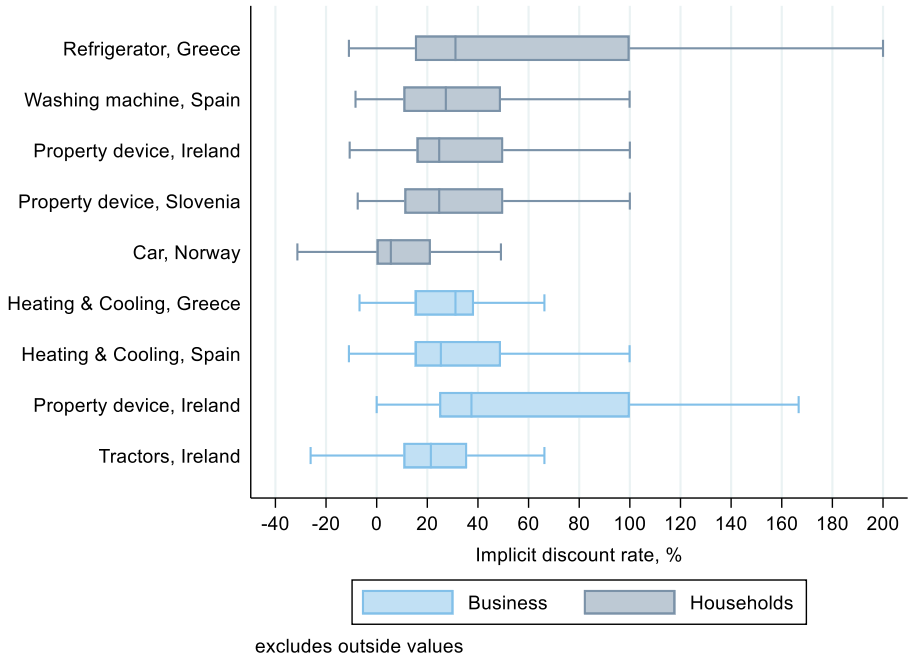


Figure 1: The IDR distributions in the household and business sectors. A box plot representation of the distribution informs about the percentile 25, 50 and 75 which forms the rectangle area (P25-P75) called the Interquartile range (IQR) and the median (P50) is indicated by the separation line in this area. On each side of the IQR, the horizontal lines represent the whiskers; they measure the distance from the P25 on the left hand side and P75 on the right side. The distance equals 1.5 times the percentile

A set of economic, attitudinal and demographic factors influence how consumers of the household and business sectors discount the future, as per Table 1. Women are likely to discount the future more heavily than men. People or companies in a more comfortable financial situation are more likely to take into account the future operating costs and pay the additional price of more EE goods. People aware of the EE label are also more likely to discount the future less. Consumers concerned about the environment are more likely to have a higher discount rate, and to be less concerned about the future operating costs. This result could be considered counterintuitive as results from prior research indicate that households who take energy mitigating actions in the form of energy savings or investment in EE can feel less concerned about the environment. Other studies (e.g. Espey and Nair, 2005; Gillingham et al., 2009) suggest that consumers who are willing to contribute to reductions in greenhouse gases or other emissions from energy production may have negative discount rates. In general, the higher discount rates are related to humans who are more concerned with present problems and tend to ignore or underestimate future risks. Lower discount rates indicate the opposite, e.g."…A zero discount rate implies that one cares about the welfare of someone a million years in the future as much as someone in the present…" (Carson and Roth Tran, 2009).

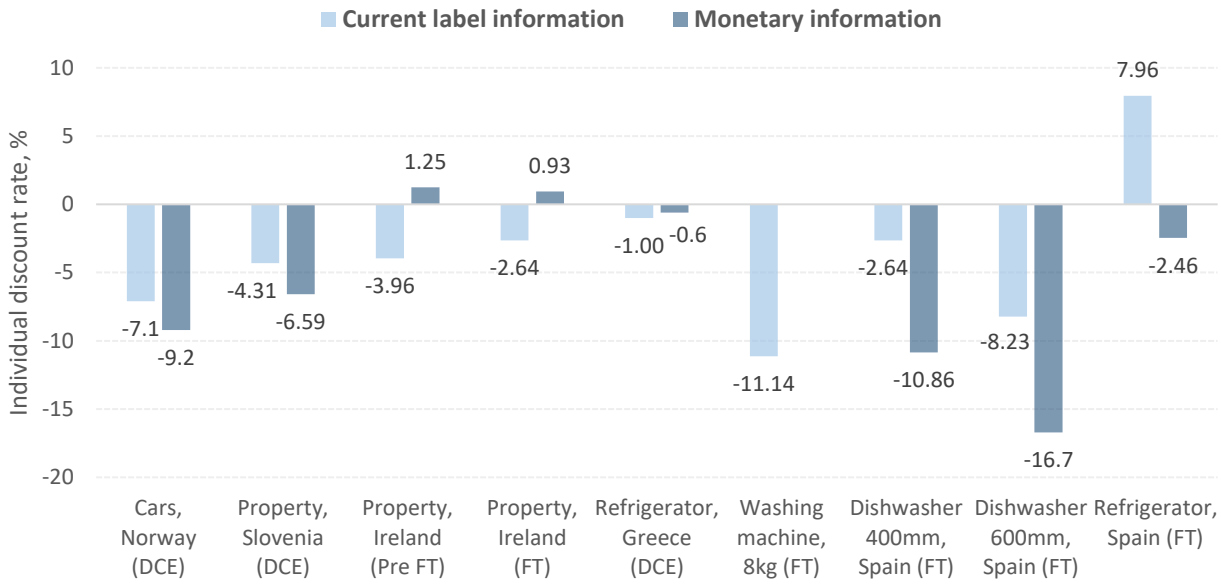
A notable difference between households and the business sector is observed: negative discounting rates are observed more frequently among households (17% of respondents) than among firms (6.5% of respondents).

Table 1: Main factors influencing the IDR in the household and business sectors

Factors	Household sector		Business sector	
	Effect on the IDR	Level of certainty†	Effect on the IDR	Level of certainty†
Sector	Significant	***	Significant	***
Country	NS	**	NS	***
Product	Significant	-	Significant	***
Case study[a]	Significant	***	Significant	***
Gender (women)	Positive	2/5	NA	NA
Income/Finance	Negative	1/5	Negative	1/4
Label awareness	Negative	2/5	Negative	1/3
Environmental concern	Positive	2/5	Positive	1/4
Initial investment cost	Negative	3/5	NS	0/3
Product lifetime	Positive	***	Positive	***

Significance of the tests: *** p<0.01, ** p<0.05, * p<0.1 and NS stands for Non-significant
†: It indicates either the level of confidence of the test or the frequency of case studies in which the factors have a statistically significant effect in the IDR distribution. Ex. 2/5 for gender means a gender effect has been found in 2 case studies over 5.
NA: Not Applicable due to lack of observations
[a]: product studied in a given country

Additional information helping consumers to calculate how much money they can save or they will spend during the lifetime of a good is likely to reduce the discount of the future. This result reinforces the role of information in reducing the EE gap. Field trials and DCEs developed in WP 4 tested experimentally the role of additional monetary information. The estimated IDR from these experiments reveals that the monetary information tends to make consumers reduce their discount rate. This result was found in five out of the eight products tested (Figure 2). In these particular cases, the average IDR is often negative: consumers are willing to pay more than what they will receive from energy savings during the lifetime of the good. The monetary information reinforces this attitude. It is important to notice that the IDR calculated in the experiments (Figure 2) and in the survey question (Figure 1) are not comparable: the lifetime of the good differs as well as the interactions with additional attributes.



FT: field trial / DCE: discrete choice experiment

Figure 2: Average IDR estimated in field trials (FT) and discrete choice experiments (DCE). Lifetime used: 18.2 years for cars, 25 years for property, 15 years for refrigerators and 10 years for appliances in Spain.

1 Terms of reference

The objective of CONSEED Work Package 5 (WP5) 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 (IDRs). This deliverable concerns the estimation of IDR.

The IDRs are estimated in an energy-related context with different methodologies: (i) a hypothetical consumer survey question asking for an internal rate of return (IRR) on an investment, (ii) a hypothetical decision from discrete choice experiments (DCEs) (WP4, Deliverable 4.2) and (iii) an actual purchase decision from field trials (WP4, Deliverable 4.1).

The discount rate data from the consumer survey (WP3, Deliverable 3.1) in the households and agriculture and services sectors were pooled, harmonized and standardized in task 5.1. The data pooling was conducted to analyse the distribution of the IDR and some socio-economic and behavioural factors that could influence it. The factors analysed are gender, income/financial situation, label awareness and environmental concern. Other discriminating factors studied are the lifetime of the product and the initial investment costs. The data pooling facilitated the testing of the difference of the IDR distribution for different goods and sectors. The data collected from DCEs and field trials were analysed separately in each case study.

Table 2: The data collected in CONSEED used in WP5

	Households sector			Business sectors		
	Appliances	Property	Transport	Agriculture	Service	
				Transport	Appliances	Property
Ireland		Residential property: CS +FT		Tractors: CS		Commercial property: CS
Norway			Cars: CS + DCE			
Spain	Washing machines: CS + FT				Heating and cooling: CS	
Slovenia		Residential property: CS + DCE				
Greece	Refrigerators: CS +DCE				Heating and cooling: CS	

CS: Consumer survey, DCE: Discrete Choice Experiment, FT: Field Trials

This deliverable is organized as follows. Section 2 presents the methodology used to estimate the IDR. Sections 3 and 4 present the findings of the consumer survey question respectively for the household and the business (agriculture and services) sectors. Section 5 presents the findings from the discrete choice and field trials and Section 6 concludes the report.

2 Methodology

Data were collected on specific populations. Results should therefore be taken with caution as they do not represent the behaviour of the general population but of specific populations. Each sample is representative of its sector at the national level (See Deliverable 3.1 of CONSEED for more details).

Table 3: Population and data collection method used in CONSEED

	Households sector			Business sectors		
	Appliances	Property	Transport	Agriculture Transport	Services Appliances	Services Property
Ireland		Homeowners, and those who plan to buy in the next five years. CAWI		Farmers owning at least one tractor and having at least 50% of their land under tillage CAWI		Firms that either bought or rented a property in the past ten years and/or plan to buy or rent in the next five. CATI
Norway			Car owners or household planning to buy one within the next 12 months CAWI			
Spain	Homeowners with a washing machine bought in the last four years. CAPI*				Hotels, hostels and cottages. CATI	
Slovenia		Homeowners, and those who plan to buy in the next five years. CAWI				
Greece	Homeowners with a refrigerator representative of the Greek population. CAWI				Hotels, hostels and cottages. CATI	

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

2.1 Elicitation of the implicit discount rate in the consumer survey question

An investment produces cash flows; an initial value and future values. The **present value** of an outcome is the value of an expected income stream determined at the date of valuation. The present value is smaller than future values when the interest rate is non-negative. The **Net Present Value** (NPV) is the amount of money paid or received (depending on whether it has a negative or positive sign) during the period, evaluated at the date of valuation. Considering the case of an energy related investment done at an initial period $t = 0$ at cost C_0 and a flow of expected benefits B_t during T years, the NPV is:

$$NPV = -C_0 + \sum_{t=1}^{T} \frac{B_t}{(1+r)^t}$$

The discount rate, also known as hurdle rate, is the minimum required rate of return that an investor is expecting to receive on an investment. It is affected by the cost of capital, the risks involved, and other factors that could directly affect the investment. The discount rate reflects the relationship between the risk and return of an investment. High discount rates indicate high-risk investments, since an investor exposed to more risk (and thus greater losses) wishes to be rewarded with higher returns. If the discount rate is high then the profits in present value terms will be lower (Box 1).In the case of energy efficiency (EE) discount rates may play an important role to determine how much someone is willing to invest now to gain some additional energy savings in the future (Train, 1985).

We are interested in estimating the value of the discount rate of the investment for which the net present value of the investment is zero, the rate of interest which makes the present value of the benefits (energy savings) equal to the present value of the investment cost, also known as the internal rate of return (IRR). This discount rate is calculated solving for the equation $NPV = 0$:

$$NPV = 0 = -C_0 + \sum_{t=1}^{T} \frac{B_t}{(1+r)^t}$$

Box 1: The net present value and the discount rate

Example:
A low-efficiency good costs €100 and consumes €30 per year in energy over its 10-year lifetime. A high-efficiency good costs €200 and consumes €10 per year over its 10-year lifetime. The high-efficiency good costs therefore €100 more and consumes €20 less per year during the 10 years.

The net present value, $NPV = -100 + \sum_{t=1}^{10} \frac{20_t}{(1+r)^t}$. If $r = 5\%$, the NPV is €54.40, the high-efficiency investment is thus better than the low-efficiency investment. If for example $r = 25\%$, the NPV is negative, equalling - €28.60, meaning that the low-efficiency investment is better than the high-efficiency investment. High discount rates reduce the value of future energy savings.

The Internal Rate of Return (IRR) solves the equation $NPV = 0$ for r. A numerical solution gives a discount rate of 15.1% (Figure 3). Therefore, if the consumer believes he/she can find an interest rate higher than 15.1% in the market, he/she will not invest in the high-efficiency good. On the contrary, if he/she believes the market cannot offer an interest rate higher than 15.1%, he/she will invest in the high-efficiency good since any discount rate lower than 15.1% generates a positive NPV.

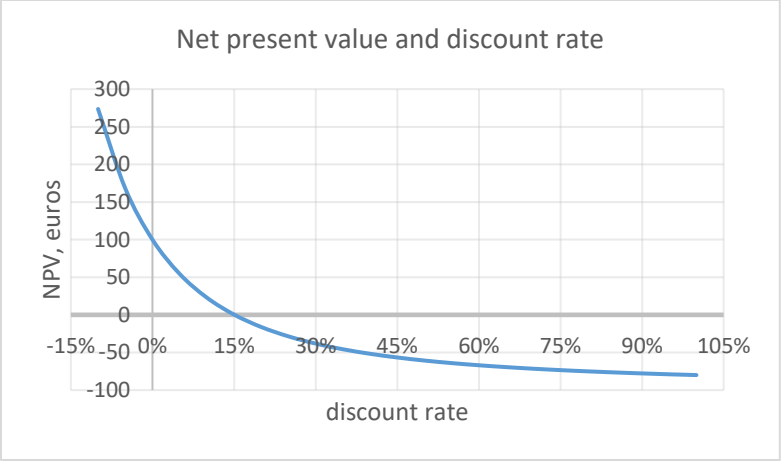


Figure 3: The net present value and the discount rate

To elicit the IRR, a **hypothetical question** was asked to the survey participants (Houston, 1983). The question was the following (Box 2):

Box 2: Example of a discounting question asked for washing machine in Spain

Suppose you could buy and install a new washing machine that will last for the next 10 years and you can decide between two models whose unique distinction relies on their energy efficiency level (energy consumption): a standard one and an efficient one that costs €{50;100;150} more but can generate a reduction in your future electricity bills.
How much would you have to save in your electricity bill approximately per year during the next 10 years in order to pay for the additional €{50;100;150} ?

a) _____euros
b) ___ Don´t know.

Why did you choose "don´t know"?

a) I don´t believe that the device will reduce my electricity costs
b) I'm not too concerned about reducing my electricity costs
c) I don´t know how to calculate future electricity savings
d) Other: _____

Each participant answered for a single additional cost of €50, €100 or €150 in this example.

This question has been adapted in each case study for the product under study (Table A 1 in appendix): washing machines, refrigerators, properties and cars in the **household sector** and tractors, heating and cooling system, properties and machinery in the **business sector**: agriculture and services (Table 2).

2.2 Elicitation of the implicit discount rate using discrete choice experiments and field trials

Discrete Choice Experiments (DCE) and field trials (FT) were implemented in CONSEED, and the results and details were presented in Deliverables 4.1 and 4.2. The willingness to pay (WTP) estimation built upon the Random Utility Model (McFadden, 1974) and is estimated with conditional logit models in DCE and with hedonic regression (Rosen, 1974) in FT. Various methods were used to estimate the IDR in DCEs and FTs.

The FT and most DCE solved for r the following equation

$$NPV = WTP = \sum_{t=0}^{n} \frac{annual\ savings_{\,t}}{(1+r)^t}$$

Where NPV is the net present value and WTP is the WTP for EE improvement, and n is the lifetime of the product.

The IDRs have been calculated both in the control and the treatment groups in order to understand how displaying information on monetary cost or savings would affect how consumers discount the future.

3 Results from the household survey question

The household surveys analysed four products: refrigerators, washing machines, heating control devices in properties, and cars. The final sample has 2,912 valid observations.

Table 4: Sample details of the households surveys

Country	Technology	Technological group	Lifetime, years	Additional cost of energy efficient product [euros]	Number of observations	Number of observations by subsample
Greece	Refrigerator	Appliances	10	50; 100; 150	476	[155;155;166]
Spain	Washing machine	Appliances	10	50; 100; 150	484	[148;163;173]
Ireland	Heating control	Property device	20	400; 600; 800	478	[159;158;161]
Slovenia	Heating control	Property device	20	400; 600; 800	410	[134;129;147]
Norway	Car	Transport	10	2800; 5600; 8400	1,064	[346;357;361]
Total					2,912	

The analysis firstly tests the existence of a country or a product effect. Secondly, it highlights the profile of respondents willing/able to answer the discounting question. Finally, it analyses the distribution of the IDR and the influence of a set of factors on the IDR, including, gender, income, environmental concern, label awareness, initial investment cost and product lifetime.

3.1 Country and product effects

The survey implemented in each country has a common part on households' behaviours and a product specific section (Deliverable 3.1, CONSEED). The discounting question (Box 2) is a product-specific question (Table 4). The possibility to disentangle a country effect from a product effect needs to be tested since different products are referred to in different countries. The test consists in comparing the distribution[1] of the IDR in the different sub samples, in comparing the median or in testing the independence between variables. These tests are applied both to the IDR value and to the ability/willingness to answer the IDR question. To test a country effect, the case studies of Ireland and Slovenia are used since they refer to the same product (heating control device in properties). The cases of Greece and Spain with distinct products

[1] Wilcoxon-Mann-Whitney test

(refrigerators and washing machines) of the same category (appliances) enables to know whether these products can be grouped in the category of appliances without losing information.

Results from these tests (Table 5) indicate that the distribution of **the IDR does not differ between two countries that analysed the same product** as well as the willingness/capacity to answer. However, a difference of distribution is observed for two different products of the same category. The rest of the analysis in the household sector considers the **existence of a product effect** based on the Epps-Singleton test (Epps and Singleton, 1986) performed over the distribution of IDR.

Table 5: Test of country effects and product effects in the household surveys

	Country effect	Product effect
Test on the IDR distribution (Epps-Singleton)	No	Yes
Median test (chi2) for IDR	No	No
Test of relation between variables (chi2) for willingness/ability to answer	No	No

Based on the test statistics from Tests and regressions from household sector surveys Table A 2 and Table A 3
Country effect: Ireland versus Slovenia for heating devices.
Product effect: washing machines and refrigerators in the appliances category.

Given the presence of a product effect in the IDR distribution, the IDR is analysed by case studies. The analysis of the willingness/ability to answer is presented as a pooled analysis given the result of the test.

3.2 Willingness or ability to answer

On average across all categories, about three out of five participants (1,781 observations) returned an amount of energy savings in the IDR question that would make them buy the EE device for a given additional cost. In the transport category, slightly less than 50% answered (516 observations), whereas in the property and appliances categories about 70% of participants (654 observations) answered (Figure 4). A series of independence tests (Table A 3) between the ability/willingness to answer and the product category show that **there is a statistically significant relation between the "Don't Knows" and the product category**; people are less likely to answer when the IDR question deals with transport. This rate of response is similar to what Houston (1983) found: about one third of responses.

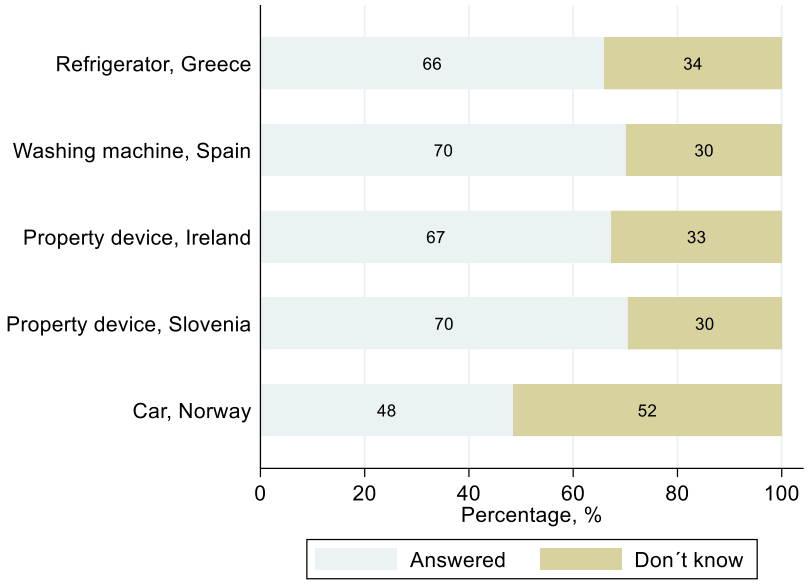


Figure 4: Rate of answers and "Don´t knows" in the household sector by product category

The analysis of the characteristics of the persons willing or able to answer the discounting question (Table 6) shows that a question referring to **transport** is less likely to be answered (21 percentage points less likely to answer). However, it cannot be excluded that this inability/non-willingness to answer results from the capacity to **deal with higher values** of the investment; people are about 16 - 25 percentage points less likely to answer when the investment cost formulated in the question is higher.

Beliefs, attitudes and awareness about energy related products also influence the likelihood of answering the question. People aware of the energy label, of energy prices and of the energy consumption of the good are about 9 - 11 percentage points more likely to answer. People believing that all goods have the same EE are less likely to be willing/able to answer a question asking them their preferences for an EE good.

Education has a positive effect on the willingness/capacity to answer; the most educated persons are about 18 percentage points more likely to calculate the savings. **Gender** also influences answers; women are about 12 percentage points less likely to answer than men. Finally, **income**[2] influences the willingness/ability to answer; households living more comfortably on their current income are about 5 - 6 percentage point more likely to answer.

[2] Qualitative measure of income description. See section 3.3.4

Table 6: Factors affecting the willingness/ability to answer the discounting question in the households sector

	Percentage point change
Factors affecting **positively** the probability to answer the IDR question	
• Willing to take a chance on new technologies to reduce energy consumption	3
• To have a good understanding of energy consumption of the good	9
• Being aware of energy prices	9.5
• Being aware of the energy label	11
• Education: higher, lower degree	11 to 18
• Living more comfortably on current income	5.5 to 6.5
Factors affecting **negatively** the probability to answer the IDR question	
• Transport sector	-21
• Higher values of initial investment costs	-16 to -25
• Belief that all good have the same energy efficiency levels	-13
• Age	-0.2
• Gender (Female=1; Male=0)	-12

Results based on the estimation of Probit models presented in Table A 4
Example of reading: People who are aware of energy prices are 9.5 percentage points more likely to answer the IDR question.

The main reasons for not returning an amount of energy savings in the question were because **respondents** either **did not know how to calculate the savings,** or **they did not believe the EE device will reduce their energy costs**. Trust in energy labels may explain why people do not buy EE products (Dieu-Hang et al., 2017; Issock et al., 2018; Spiliotopoulos et al., 2019). A slight difference is observed regarding the justifications in the transport sector; less people than in other sectors justify their non-answer with the bounded rationality motive ("Cannot calculate savings") and more people are less concerned about energy cost reduction (Figure 5).

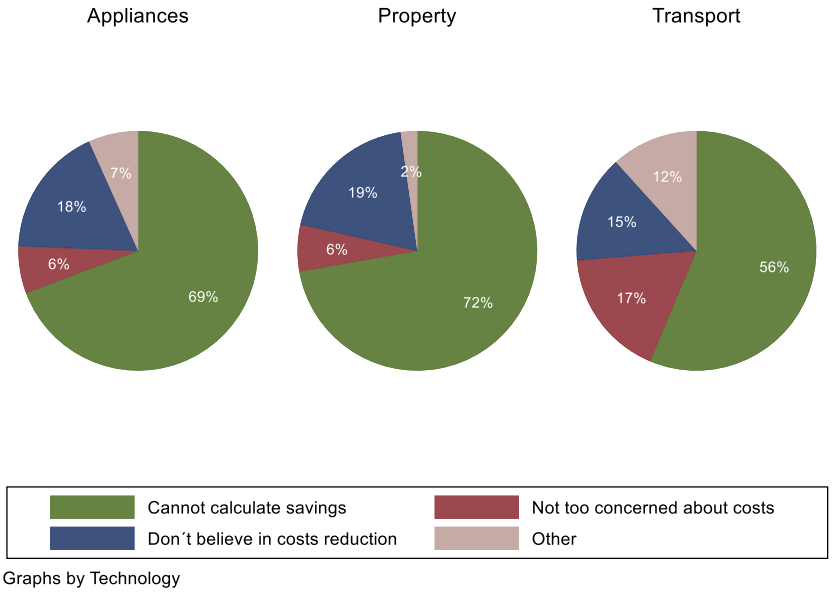


Figure 5: Motives of non-answers to the discounting question in the households sector

3.3 The value of the implicit discount rate

We analyse the IDR distribution and its statistical relation with labelling and socio-economic factors such as gender, income, environmental concern, label awareness, product lifetime and initial investment costs.

3.3.1 The IDR distribution

The distribution of the IDR, as estimated from the consumer surveys, is graphically represented with boxplots[3] (Figure 6) and varies between product and country categories[4] (Kruskall-Wallis test. Pr>Chi2(4)=0.00). The median IDR for transport goods (6%) is much smaller than for appliances (31% in Greece and 27% in Spain) or property device (25% in Ireland or Slovenia). All products' distributions are positively skewed. In the case of appliances in Greece, the skewness to the right and the interquartile range are greater than for the other goods, meaning that more data will be observed for high value of the IDR. A large variance of the IDR has been observed in all case studies. The mean, standard deviation, median and confidence intervals[5] of the median are provided in Table 7.

[3] A box plot representation of the distribution informs about the percentile 25, 50 and 75 which forms the rectangle area (P25-P75) called the Interquartile range (IQR) and the median (P50) is indicated by the separation line in this area. On each side of the IQR, the horizontal lines represent the whiskers; they measure the distance from the P25 on the left hand side and P75 on the right side. The distance equals 1.5 times the percentile.
[4] Kruskal-Wallis test: Pr z>Chi2(4)=0.0001.
[5] Based a binomial method that makes no assumptions about the underlying distribution of the IDR.

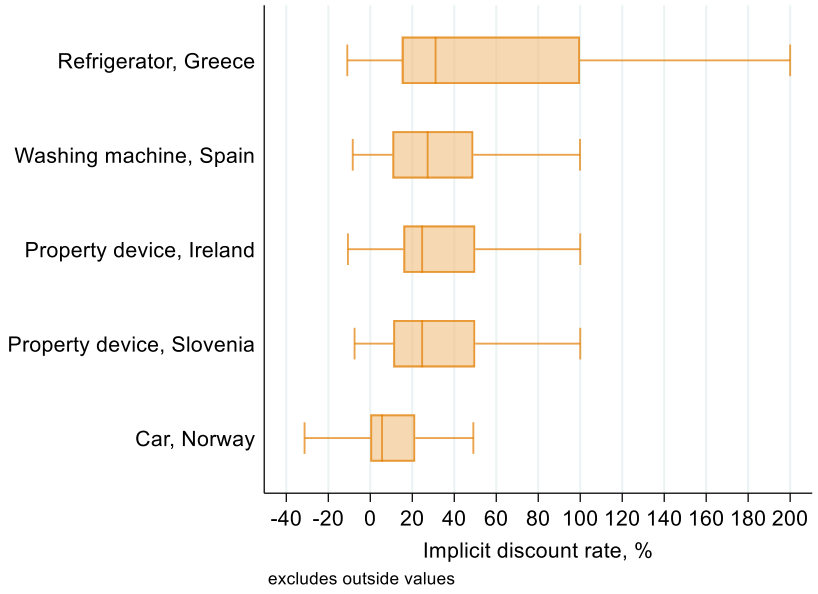


Figure 6: Box-plot representation of the IDR distribution in the household sector

Table 7: Descriptive statics of the IDR in the household sector

	Number of observations	Mean	Median	95% CI of the median	Stand. Dev.
Refrigerator, Greece	314	62	31	[27;38]	76
Washing machine, Spain	340	37	27	[20;31]	37
Property device, Ireland	322	41	25	[25;25]	39
Property device, Slovenia	289	36	25	[25,25]	37
Car, Norway	516	22	6	[4;8]	44

3.3.2 The negative implicit discount rates

A negative IDR occurs when the sum of cash flows returns, namely here the energy savings, is less than the initial investment cost. Investors in this case will be losing money at the rate of the negative IDR if we consider only the direct financial benefits. Altruistic behaviours can explain why some people contribute more than others to a common good such as environmental and air quality (Dietz, 2015; Nguyen et al., 2017). Those people would thus be willing to pay more for EE for environmental motivations. Other reasons could lie in the uncertainty relative to the future electricity price: an anticipation of higher energy prices would encourage consumers to invest earlier in EE (Heinzle, 2012). The investment in EE would be seen as a hedge against the risk of rising energy prices. Other benefits include, for example in property, a more comfortable living space, improved health benefits of cleaner indoor air and higher property value. In our sample we observe on average 17 percent of cases with a negative IDR. **The share of negative IDR is**

statistically significantly different between case studies (Pr z>Chi2(4)=0.000, Figure 7), up to one third of the Norwegian sample is willing to invest in the good (cars) even if the flow of return is smaller than the initial cost.

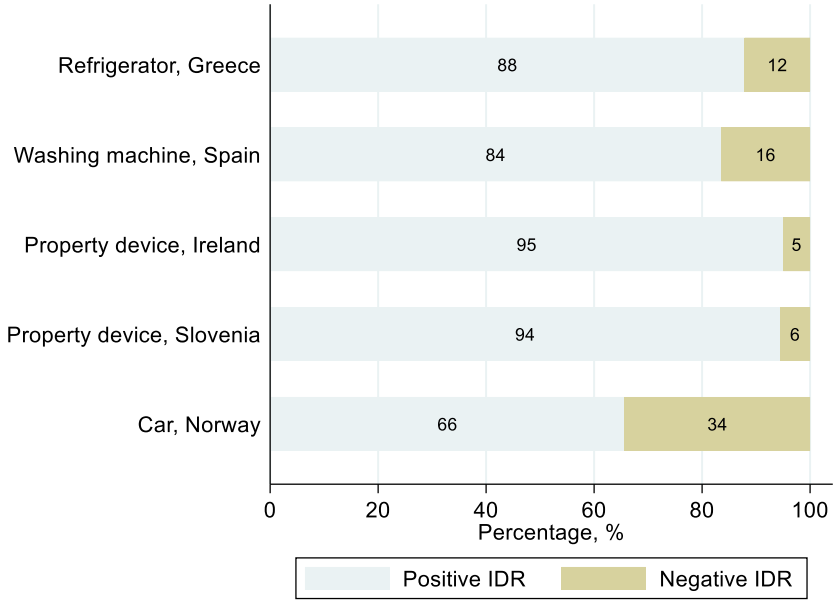


Figure 7: Negative versus positive IDR in the household sector

A series of test of independence suggests there is no product effect within the appliances category between refrigerator and washing machine (Pr z > Ch2(1)=0.112) and no country effect for the same product (Pr z > Ch2(1)=0.753) between Ireland and Slovenia for property heating devices. Altruistic behaviours proxied here by the negative IDR values are therefore independent of the product tested within the same category (washing machines or refrigerators in the appliances category) and independent of the country.

An analysis of the characteristics of the household with a negative IDR (Table 8) reveals that it is more likely to observe negative IDRs for the transport goods and appliances than for property devices. People valuing EE as an *important or very important* attribute are also more likely to have a negative IDR. This hints that EE investments may have been perceived by households as a way to reduce their environmental impacts (Deliverable 3.1, CONSEED) which would be in line with the altruistic behaviours hypothesis. However, people for whom the price of the good is an *important or very important* attribute will be less likely to have a negative IDR, as could be expected.

Table 8: Factors affecting the probability of having a negative IDR in the household sector

	Percentage points change
Factors affecting **positively** the probability to having a negative IDR	
• Appliances sector (compared to property device)	8.5
• Transport sector (compared to property device)	31.8
• Being aware of the energy label	5
• Value energy efficient as important or very important attribute	6.7
• Age	0.1
Factors affecting **negatively** the probability to answer the IDR question	
• Value the price as important or very important attribute	-16.6

Results based on the estimation of Probit model presented in Table A 5*. Only statistically significant factors are reported here*
Example of reading: People aware of energy labels are 5 percentage points more likely to have a negative IDR.

3.3.3 The gender effect

We found a statistically significant effect of gender in the IDR distribution (Figure 8, Table 9) in Slovenia (Pr>z=0.00661) and Norway (Pr>z=0.0664) where women's median IDR is higher than men's median IDR. This difference can be up to 10 points in the case of washing machines in Spain. **Women would therefore tend to discount the future more than men; they give less importance to future energy savings than men would do**.

Table 9: Median and 95% Confidence Interval (CI) of IDR by gender in the household sector

		Refrigerator, Greece	Washing machine, Spain	Property device, Ireland	Property device, Slovenia***	Car, Norway***
Male	Median	29	21	25	18	4
	95% CI	[21;38]	[15;27]	[25;25]	[14;25]	[4;8]
Female	Median	31	31	27	25	8
	95% CI	[23;49]	[27;38]	[24;33]	[24;31]	[4;10]

*** p<0.01, ** p<0.05, * p<0.1 for Epps-Singleton test.

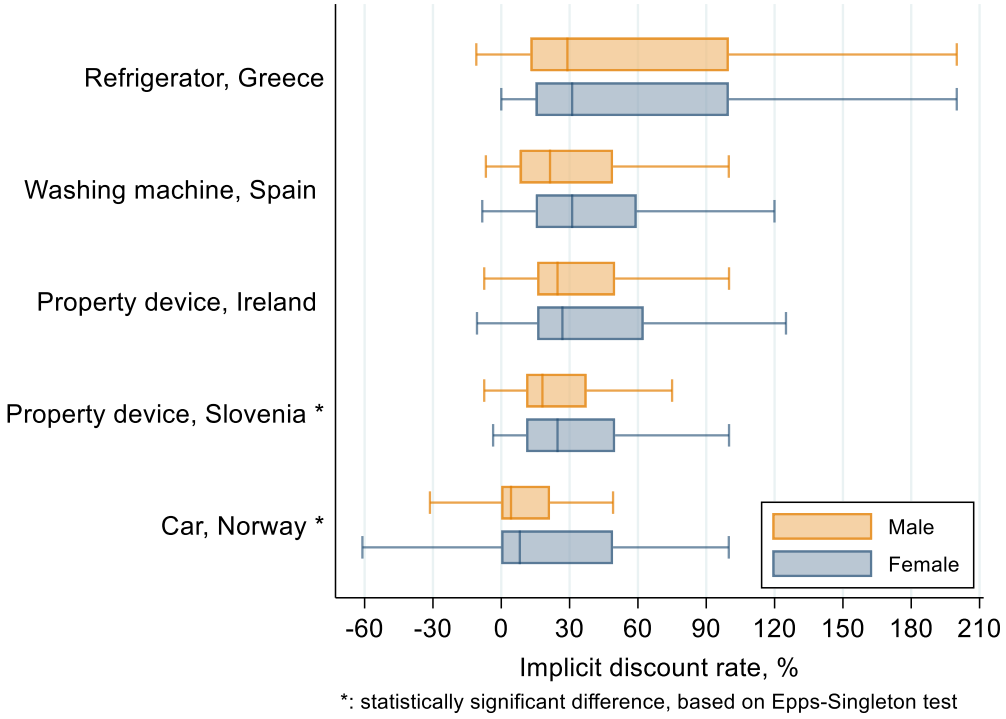


Figure 8: Gender effect in the IDR distribution in the household sector

3.3.4 The income effect

The level of income has been asked on a qualitative judgement of how households live with their current income, following OECD standards (OECD, 2014). Statistically significant differences are observed between case studies regarding the income judgment (Pr>Chi2(16)=0.00). In Greece and Ireland, more respondents with financial difficulties are observed (Figure 9).

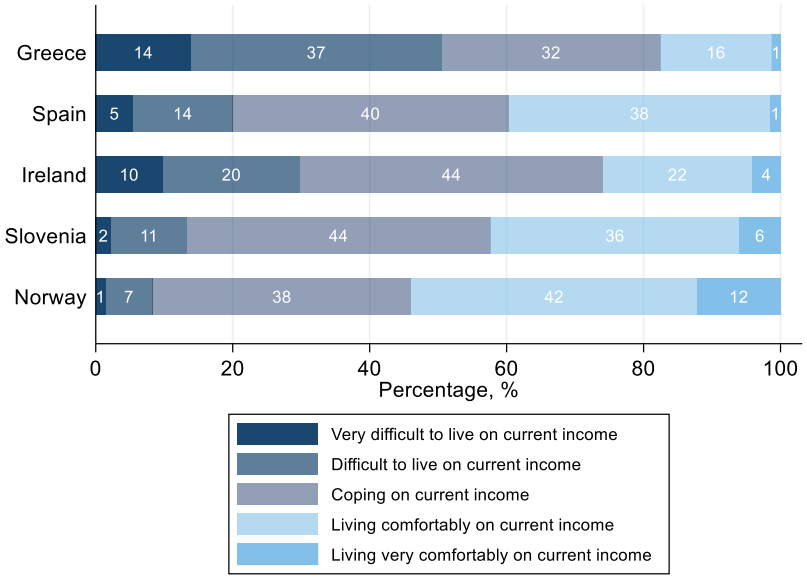


Figure 9: Degree of income comfort per country in the household sector

The five initial categories (Figure 9) were grouped in three categories in order to improve graphical readability[6]. The IDR distribution differs with the level of income comfort, **people with higher living comfort tend to discount less the future benefits** they will receive from investing in an EE good (Table 10). This has been found in the case of Spain[7] (Figure 10, Table 10). In Norway the change of IDR distribution is observable from people having difficulties to live with current income: more cases of high IDR are encountered among the poorer part of the population as well as a greater variability of IDRs in this income category.

Table 10: IDR statistics per income comfort category in the household sector

		Refrigerator, Greece	Washing machine, Spain***	Heating control, Ireland	Heating control, Slovenia	Car, Norway
Difficult or very difficult to live on current income	Median	31	46	25	25	8
	95% CI	[27;49]	[38;49]	[25;33]	[16;50]	[0;100]
Coping on current income	Median	31	27	25	25	6
	95% CI	[15;49]	[21;37]	[25;28]	[18;27]	[4;10]
Living comfortably or very comfortably on current income	Median	23	15	25	25	4
	95% CI	[15;31]	[15;21]	[25;33]	[19;25]	[4;8]

*** p<0.01, ** p<0.05, * p<0.1 for Kruskal-Wallis test.

[6] Similar results were obtained with five categories.
[7] Kruskal-Wallis test: Pr>Chi2(2)=0.000 for Spain. No statistical difference of IDR distribution has been found in other countries, based on both the median test and the Kruskal-Wallis test.

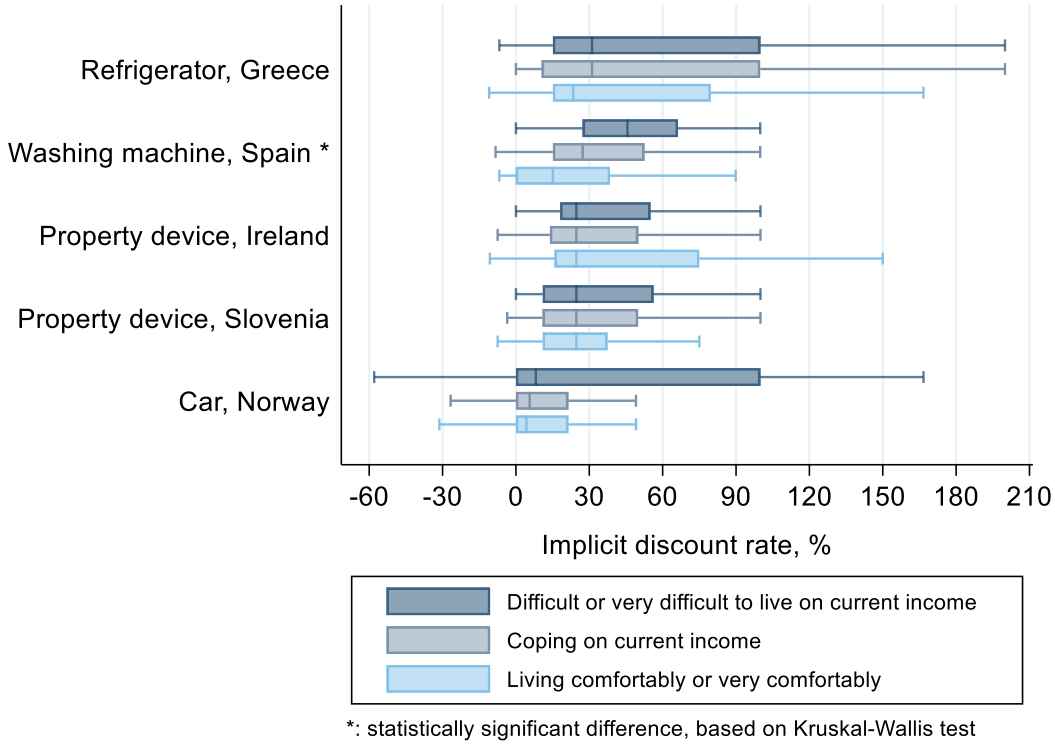


Figure 10: Income effect on the IDR per country in the household sector

3.3.5 The effect of labelling information

The information regarding the energy label varies significantly[8] between cases studies. Most of the respondents are aware of the energy label of their good (Figure 11) except in the case of cars in Norway.

[8] Pr >Chi2(4)=0.00

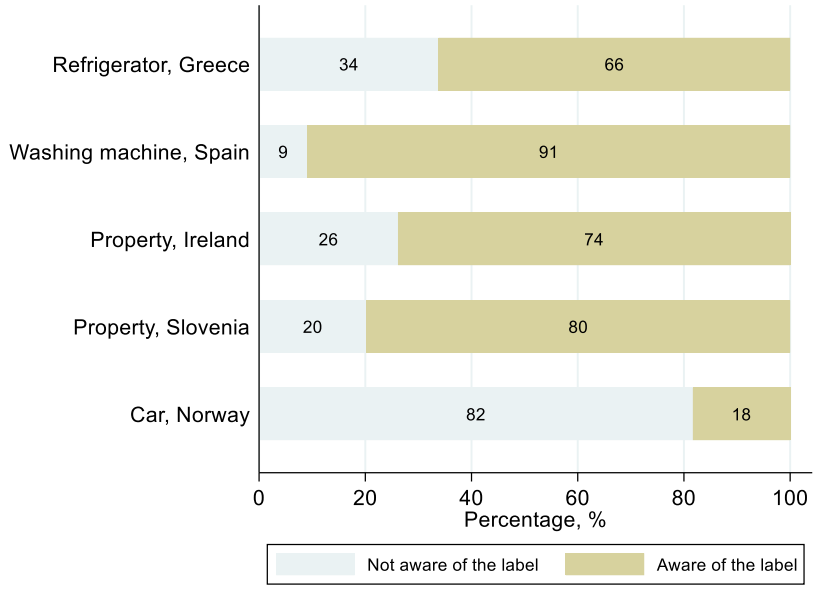


Figure 11: Awareness of the energy labels in the household sector

We find a statistically significant difference of the IDR distributions depending on the level of awareness for washing machines in Spain (Pr>z=0.008) and properties in Slovenia (Pr>z=0.0353). The awareness of the EE label tends to reduce the IDR (Table 11, Figure 12); **people aware of the label give a higher importance to future energy savings.** This reveals the effectiveness of the label in changing the weights given by consumers to the operating costs (future monetary flows) in their decision.

Table 11: Median and 95% confidence interval of IDR by awareness of the energy label in the household sector

		Refrigerator, Greece	Washing machine, Spain***	Property device, Ireland	Property device, Slovenia ***	Car, Norway
Not aware of the label	Median	31	31	28	25	6
	95% CI of median	[15;40]	[24;50]	[25;47]	[15;35]	[4;8]
Aware of the label	Median	31	27	25	25	4
	95% CI of median	[24;38]	[15;31]	[25;25]	[19;25]	[3;11]

*** p<0.01, ** p<0.05, * p<0.1 for the Epps-Singleton test

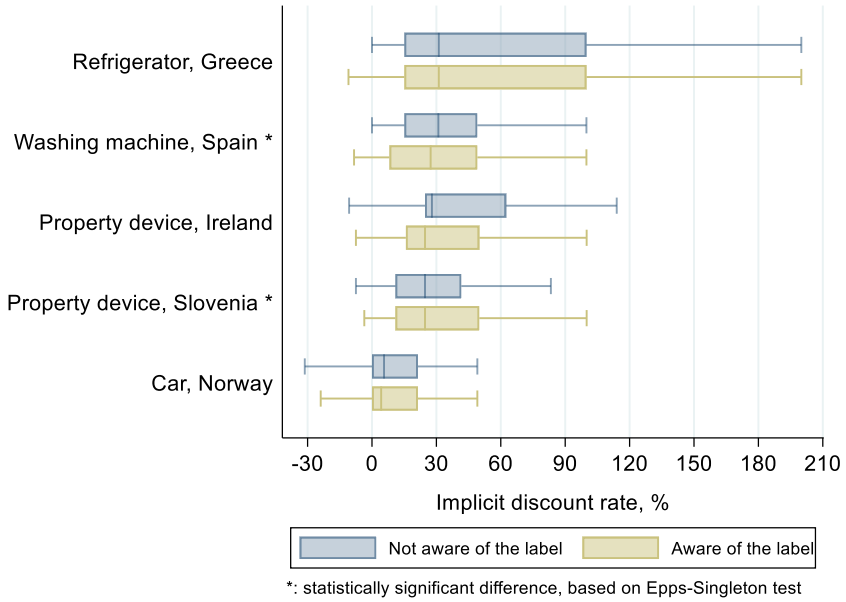


Figure 12: The effect of label awareness on the IDR in the household sector

3.3.6 The effect of environmental concern

Interviewed people were asked to rate their level of concern about the environment, such as pollution, global warming or climate change. Globally people declared a high level of environmental concern (Figure 13), this level of concern is statistically different between case studies (Pr>Chi2(12)=0.00). Less people concerned or extremely concerned are observed in Norway and Slovenia.

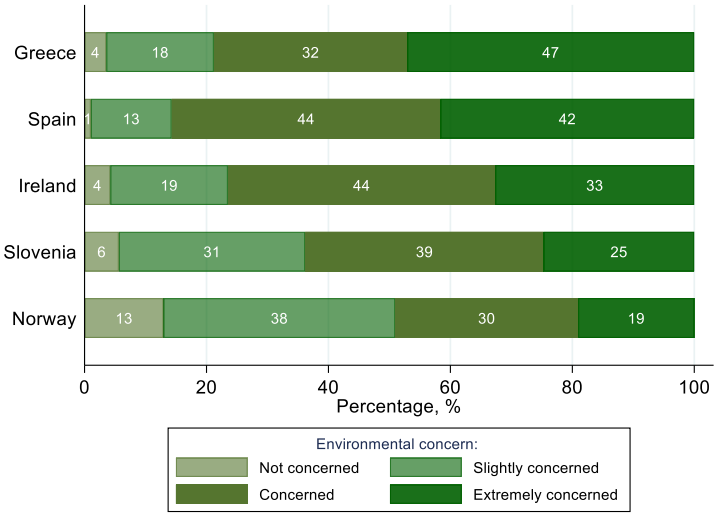


Figure 13: Degree of environmental concern in the household sector per country

The four initial categories to describe the environmental concern were grouped in two categories for the analysis[9]: people not or slightly concerned and people concerned or extremely concerned. A significant difference in the distribution of the IDR with respect to the degree of environmental concern is only found in Spain (Pr>z=0.012) and in Norway (Pr>z=0.019). **People *concerned* or *extremely concerned* about the environment have a higher discount rate, i.e. they value less future energy savings** (Table 12, Figure 14)[10]. However, the differences are small and not homogenous between case studies.

In Spain, the median IDR is larger for the pro-environmental individuals while it is smaller in Norway. Furthermore, in Norway, the distribution is much wider for pro-environmental individuals than in Spain. All in all, the role of environmental attitudes lacks clearer evidence. This result could be due to potential feedback effects of climate change concern on environmentally friendly attitudes such as EE investment: consumers who already invest in EE behaviours can feel less concern about the climate change. Another potential reason could be related to the semantic of concern and the negative reference made in the question "*pollution, global warming or climate change*". Since concerns reflect worries, people might be willing to prefer the present if the future environmental situation is to be worst.

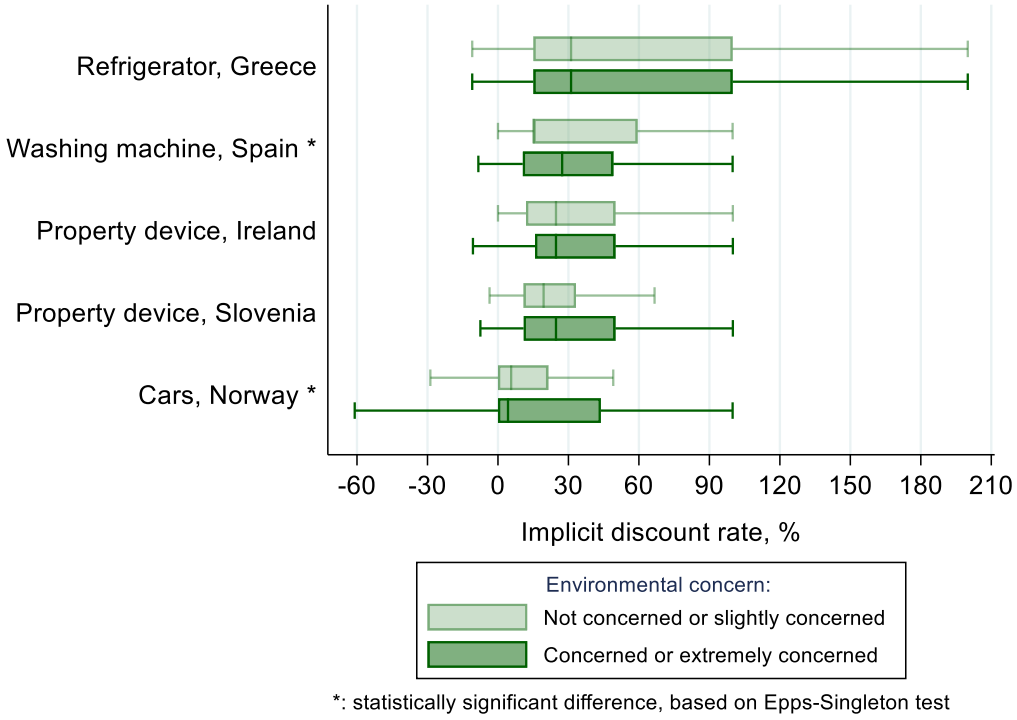


Figure 14: Environmental concern effect on the IDR per country in the household sector

[9] For comparability with the business sector.
[10] For Norway, although the median IDR decreases, the average IDR increases with environmental concern level

Table 12: IDR statistics according to the degree of environmental concern in the household sector

		Refrigerator, Greece	Washing machine, Spain***	Property device, Ireland	Property device, Slovenia	Car, Norway***
Not or slightly concerned	Median	31	15	25	19	6
	95% CI of median	[15;63]	[15;38]	[20;33]	[16;25]	[4;10]
Concerned or very concerned	Median	31	27	25	25	4
	95% CI of median	[23;38]	[22;31]	[25;27]	[25;33]	[4;8]
*** p<0.01, ** p<0.05, * p<0.1 for Epps-Singleton test						

3.3.7 The effect of lifetime and initial cost assumptions

Three balanced subsamples were designed in order to test the presence of an anchoring effect. Individual decisions can be influenced by the initial value presented by the researcher (Tversky and Kahneman, 1974). In the IDR question, such an effect could arise from the initial investment cost decided by the researcher based on market values. The lifetime of the good is another possible source of anchoring but it has been kept fixed in each case study to limit the number of subsamples: 10 years or 20 years.

3.3.7.1 The effect of the initial investment costs

In each country, the survey has been implemented on three sub samples (Table 4) to test the bias that would result from the value of the initial investment cost. We tested this bias in each case study and find a statistically significant difference of the IDR distribution in the cases of cars in Norway (Kruskal-Wallis test: Pr >Chi2(2)=0.005), property device in Slovenia (Kruskal-Wallis test: Pr >Chi2(2)=0.01) and washing machine in Spain (Kruskal-Wallis test: Pr >Chi2(2)=0.0003). We found that the IDR decreases as the initial investment cost increases in these countries (Figure 15, Table 13)[11]; **people tend thus to discount less future benefits and give more importance to future energy savings when the investment cost is high.**

[11] For Ireland, although the median IDR is unchanged, the average IDR decreases with the initial cost

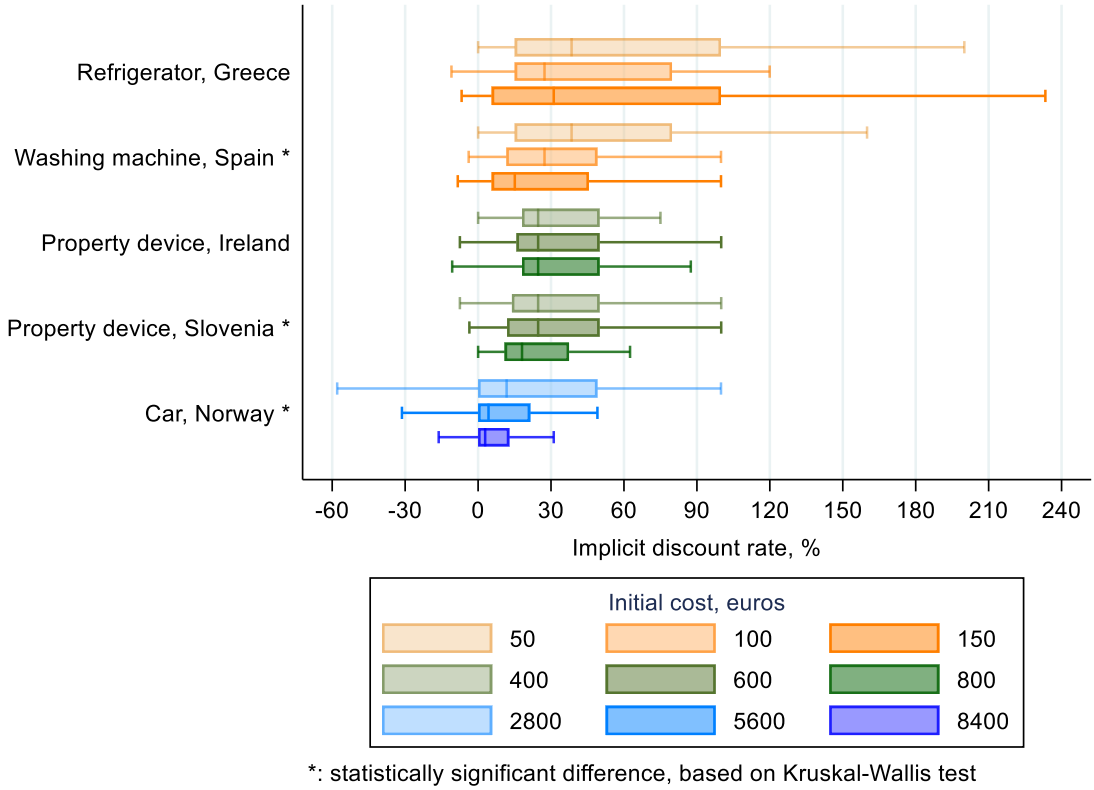


Figure 15: The IDR distribution by initial investment cost in the household sector

Table 13: IDR statistics according to the initial investment cost in the household sector

Initial investment costs		Refrigerator, Greece	Washing machine, Spain*	Property device, Ireland**	Property device, Slovenia	Car, Norway***
50 €	Median	38	38			
	95% CI of median	[25;80]	[27;49]			
100 €	Median	27	27			
	95% CI of median	[21;49]	[15;31]			
150 €	Median	31	15			
	95% CI of median	[15;31]	[15;31]			
400 €	Median			25	25	
	95% CI of median			[25;25]	[25;37]	
600 €	Median			25	25	
	95% CI of median			[16;33]	[16;33]	
800 €	Median			25	18	
	95% CI of median			[25;33]	[11;25]	
2800 €	Median					12
	95% CI of median					[8;21]
5600 €	Median					4
	95% CI of median					[4;5]
8400 €	Median					3
	95% CI of median					[1;11]
*** p<0.01, ** p<0.05, * p<0.1 for Kruskall-Wallis test						

3.3.7.2 The lifetime of the good

The IDR question was designed for a given and invariant horizon of the investment in each country, i.e. the lifetime of the product. The lifetime was 10 years for home appliances (refrigerators, washing machines) and cars, and 20 years for property heating devices. We find a statistically significant difference between the two horizons (Epps-Singleton test, Pr>z=0.000); **a longer lifetime tends to make people have a higher discount rate** (Figure 16, Table 14). However, we cannot exclude that this difference is not partially due to the presence of a product or initial cost effect.

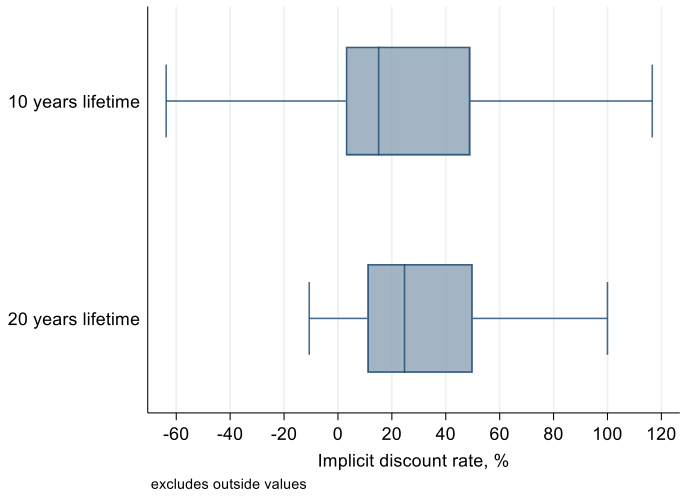


Figure 16: The distribution of the IDR by product's lifetime in the household sector

Table 14: IDR statistics according to the lifetime of the product in the household sector

Lifetime	Median	95% CI of the median	Stand. Dev.
10 years	15	[15;15]	55
20 years	25	[25;25]	38

4 Results from the business survey question

The survey implemented in the business sectors analysed three products: heating and cooling systems (H&C) in the hotel sector, heating control devices in commercial properties, and tractor consumption devices in agriculture. The final sample has 762 valid observations (Table 15).

Table 15: Sample details of the business sectors surveys

Country	Technology	Sector	Lifetime, years	Additional cost of energy efficiency product, [euros]	Number of observations	Number of observations by subsample
Greece	Heating and cooling system	Hotel, Services	10	500; 1,000; 1,500	98	[34;34;30]
Spain	Heating and cooling device system	Hotel, Services	10	200;250;300	197	[64;64;69]
Ireland	Heating control device	Property, Services	20	400; 600; 800	168	[57;63;48]
Ireland	Tractor device	Agriculture	10	2,000; 3,000; 4,000	299	[91;104;104]
Total					762	

The following analysis firstly tests the existence of a country or a product effect. Secondly, it analyses the profile of respondents' willingness/ability to answer the discounting question. Lastly, it analyses the distribution of the IDR by case study and the influence of a set of factors such as gender, financial situation, environmental concern, label information, initial cost investment or product lifetime.

4.1 Country and product effects

The surveys implemented in the business sector enable to test the presence of a country effect and a product effect. In Ireland, we tested the presence of a product/sector effect (tractors and property heating device). The country effect was tested in the case of heating and cooling systems in Greece and Spain. These tests were done both for the IDR distribution and the capacity/ability to answer the IDR question.

Table 16: Test of country effects and product effects in the business sector

	Country effect	Product/Sector effect
Test on the IDR distribution (Epps-Singleton)	No	Yes
Median test (Chi2) for IDR	No	Yes
Test of relation for willingness/ability to answer (Chi2)	No	No
Based on the test statistics from Table A 6		

Results of the tests (Table 16) show that the **ability/willingness to answer is neither related to the product/sector nor to the country under study**: the ability to answer is thus independent of the country considered and independent of the product under study. However, the distribution of the IDR is different

(i) when different products (tractors and property devices) are considered in the same country (Ireland); and (ii) when the same product (heating and cooling system) is considered in different countries. **We therefore detected the presence of a product/sector effect and no country effect in this sample regarding the IDR distribution.**

4.2 Willingness or ability to answer

We observe a significant difference in the ability/willingness to answer the IDR between Ireland and Greece or Spain (Pr>Chi2(1)=0.000); more people answered the question in Ireland. As previously tested, there is no difference between Spain and Greece, and between the two products studied in Ireland regarding this issue.

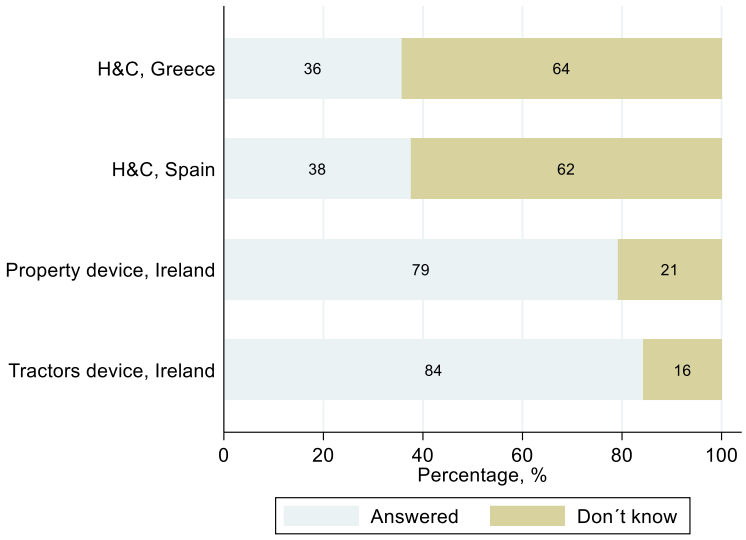


Figure 17: Rate of answers and "Don´t knows" in the business sector by product category

A regression analysis helped to inform about the profile of those willing/able to answer the IDR question (Table 17). The product tested has a significant role: people asked about property and transport related goods (both in Ireland) are more likely to answer than when asked about appliances. Firms aware of the energy label are more likely to answer as well as firms willing to take a chance on new technologies to reduce their energy consumption and firms concerned about the environment.

Table 17: Factors affecting the willingness/ability to answer the discounting question in the business sector

	Percentage point change
Factors affecting **positively** the probability to answer the IDR question	
• Willing to take a chance on new technologies to reduce energy consumption	9-11
• Being aware of the energy label	15
• Property sector (reference Appliances)	38-44
• Transport (reference Appliances)	52
• Environmental concern	12-15

Results based on the estimation of Probit models presented in Table A 7. *Only statistically significant factors are reported here*
Example of reading: people aware of energy prices are 15 percentage points more likely to answer the IDR question

The main reasons for not answering deals with the **ability to calculate the energy savings**. In the case of commercial properties, **the landlord-tenant problem** is also the main limitation; tenants are more likely to protest and not answer as they feel less concern about an investment that would be made by landlords (Figure 18).

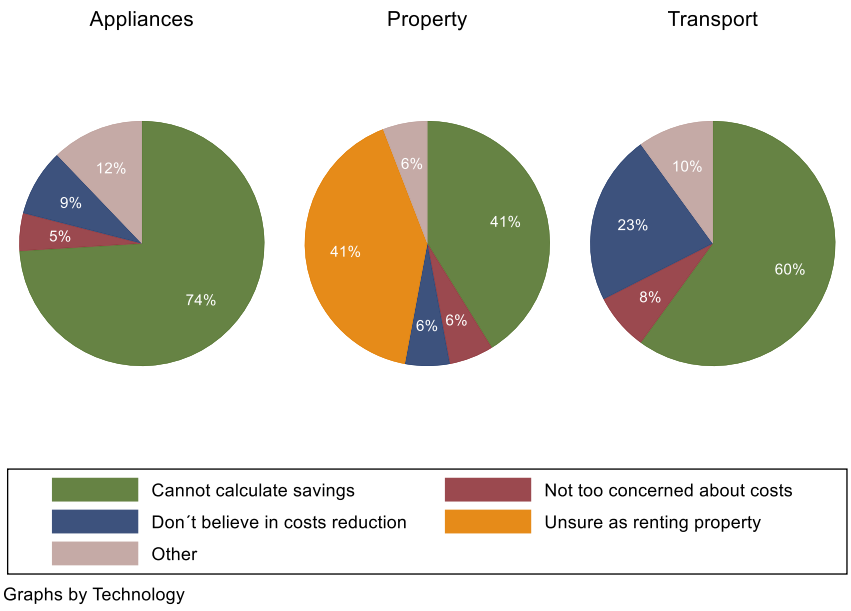


Figure 18: Motives of non-answers to the discounting question in the business sector

4.3 The value of the implicit discount rate

We analyse the IDR distribution and its statistical relation to socio-economic and behavioural factors such as gender, financial situation, environmental concern, label awareness, product lifetime and initial investment costs.

4.3.1 The IDR distribution

A significant difference has been found in the IDR distribution between the different case studies (Kruskal-Wallis test: Pr>Chi2(3)=0.000); a higher median discount rate is observed for commercial property device than for heating and cooling or tractors (Figure 19, Table 18).

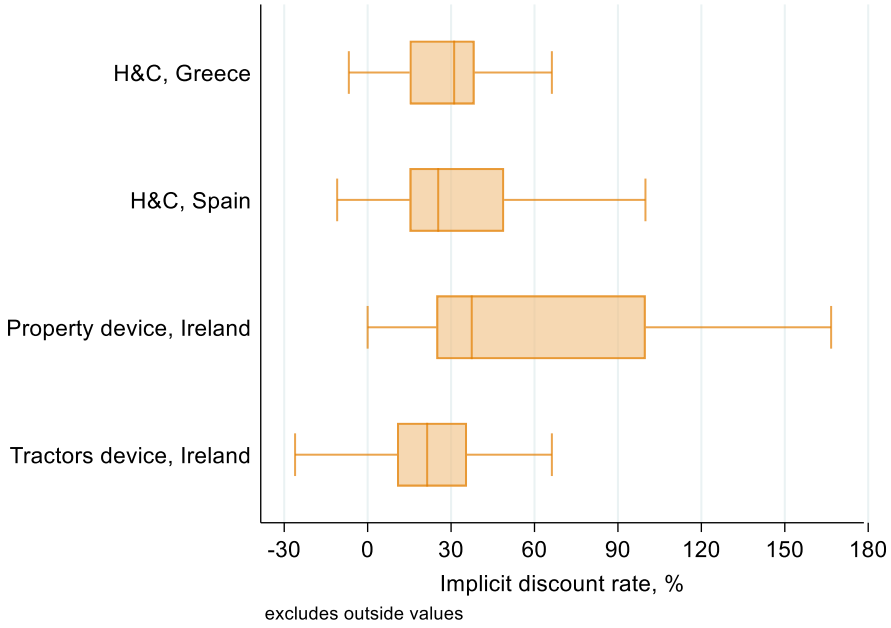


Figure 19: Box plot representation of the IDR distribution in the business sector

Table 18: Descriptive statics of IDR in the business sector

	Number of observations	Mean	Median	95% CI of the median	Stand. dev
H&C, Greece	35	35	31	[24;31]	28
H&C, Spain	74	35	25	[15;38]	31
Property device, Ireland	133	55	37	[33;50]	38
Tractors device, Ireland	252	29	21	[21;21]	28

4.3.2 The negative implicit discount rates

A negative IDR means the firm is willing to lose money at the rate of the negative IDR. This behaviour could be explained by altruistic reasons, reputational issues for the firms, or aversion to rising energy prices. In our sample, on average 6.5% of firms have a negative IDR which sums up to 32 observations over 494 who reported an amount of energy savings. We observe a significant difference between case studies (Pr>Chi2(3)=0.012): more cases with negative IDR are observed in Spain and Ireland.

Figure 20: The positive and negative IDRs in the business sector

4.3.3 The gender effect

Gender identification was asked in the hotel sector in Greece and the agricultural sector in Ireland. The sample is male-dominated, particularly in the agricultural sector of Ireland where only 2% of women answered to the survey (4 valid observations for the discounting). In Greece, 36% of women answered (35 observations of which only 10 answered the discounting question). We consider those samples too small and not representative to test gender differences.

4.3.4 The financial situation effect

The role of the financial situation in the discount rate has been tested with different indices. In the services sectors in Ireland and Spain, respondents were asked to grade their financial situation in a 10 unit scale[12]. In the agricultural sector in Ireland, the financial question was the same as for households, based on OECD[13]. For comparability purposes, three categories have been created: those firms with financial difficulties, those coping on current finance and those judging their financial situation as comfortable[14] (Figure 21).

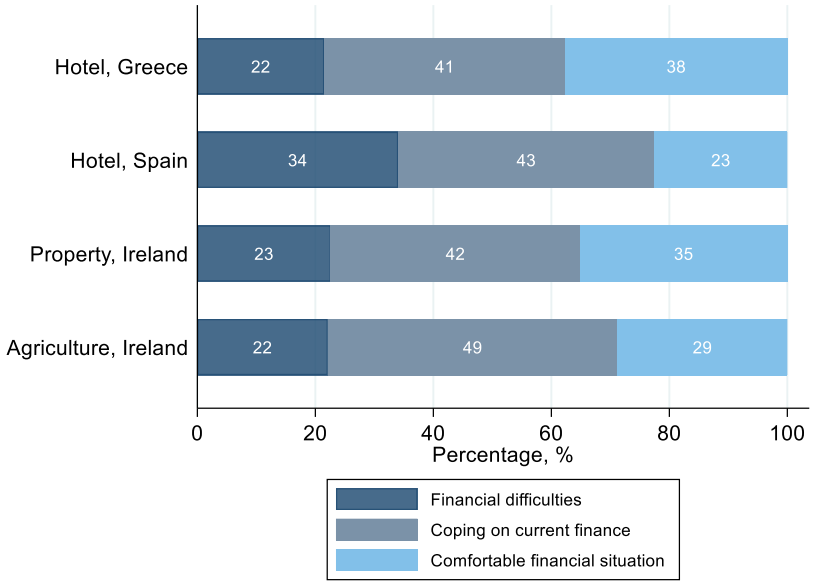


Figure 21: The financial situation in the business sector

In the case of commercial property heating device in Ireland, a significant difference of IDR has been found according to the financial situation (Kruskal-Wallis test: Pr >Chi2(2)=0.053). Irish companies with a more comfortable financial situation tend to have a lower IDR (Figure 22, Table 19); **a better financial situation enable firms to lower their discount of the future and give more weight to the flow future energy expenses.** No relation has been found between the IDR and the financial situation either for heating and cooling system in hotels in Spain (Kruskal-Wallis test: Pr >Chi2(2)=0.179) or in Greece (Kruskal-Wallis

[12] From 1 for severe difficulties to 10 for very or extremely good.

[13] Respondents were asked to evaluate their living situation: *finding it very difficult to live on current income, very difficult to live on current income, coping on current income, living comfortably on current income or very comfortably on current income*

[14] The 3 groups are determined by the 1st quintile for the Likert scale score for the group with financial difficulties (score ≤5) and the last quintile for the group with a comfortable financial situation (score ≥8).

test: Pr >Chi2(2)=0.363), or for tractors in the agricultural sector in Ireland (Kruskal-Wallis test: Pr >Chi2(4)=0.222).

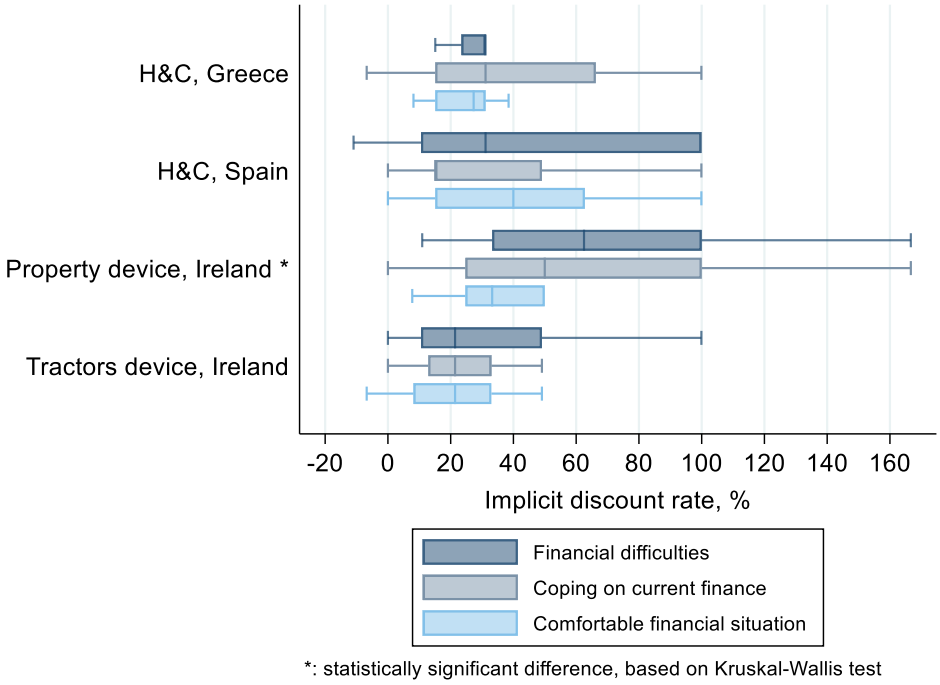


Figure 22: Income effect on the IDR in the business sector

Table 19: IDR statistics per financial comfort category in the business sector

		H&C, Greece	H&C, Spain	Property device, Ireland**	Tractors device, Ireland
Financial difficulties	Median	31	31	62	21
	95% CI	[16;68]	[14;90]	[40;100]	[21;37]
Coping on current finance	Median	31	15	50	21
	95% CI	[18;58]	[15;34]	[30;62]	[21;23]
Comfortable financial situation	Median	27	40	33	21
	95% CI	[15;36]	[16;62]	[31;37]	[15;21]

*** p<0.01, ** p<0.05, * p<0.1 for Kruskal-Wallis test.

4.3.5 The effect of labelling information

There is a statistically significant difference between the case studies[15] with respect to the awareness of the label (Pr<chi2(2)=0.000). More respondents are aware of the energy label in Ireland in the case of property labels than in Greece or Spain relating to heating and cooling systems (H&C).

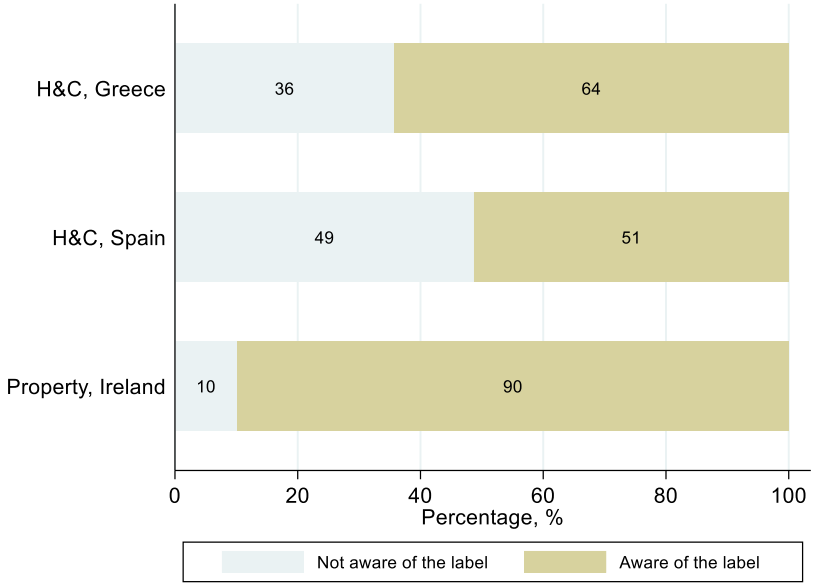


Figure 23: Awareness of the energy labels in the business sector

We found statistically significant differences in the distribution of the IDR with respect to the energy label awareness in the case of heating device in Ireland (Epps-Singleton test: Pr>z=0.051) and in H&C in Spain (Epps-Singleton test. Pr>z=0.019) (Figure 24, Table 20). In H&C in Spain, the label awareness increases the median IDR, while for property devices in Ireland, it decreases the IDR. Results should be taken with caution given the small number of firm not aware of the label in Ireland (10 observations).

[15] The awareness question in the survey was not applicable to the case of tractors in Ireland.

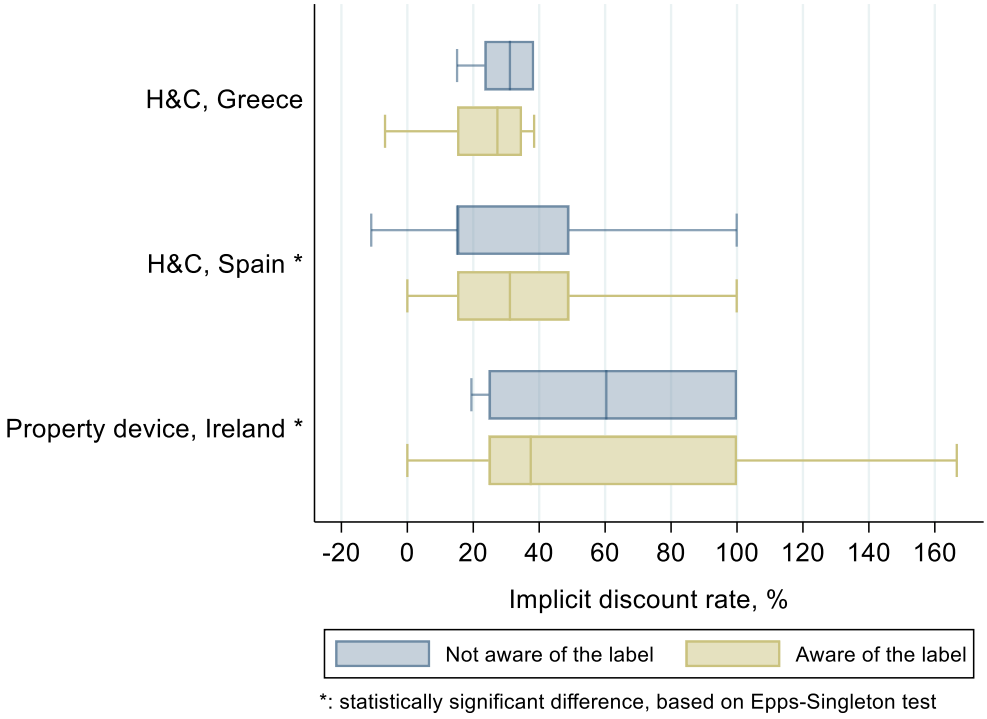


Figure 24: The effect of label awareness on the IDR in the business sector

Table 20: Median and 95% confidence interval of IDR by awareness of the energy label in the business sector

		H&C, Greece	H&C, Spain***	Property device, Ireland**
Not aware of the label	Median	31	15	60
	95% CI of median	[21;56]	[15;32]	[25;100]
Aware of the label	Median	27	31	37
	95% CI of median	[15;31]	[17;49]	[34;50]

*** p<0.01, ** p<0.05, * p<0.1 for Epps-Singleton test.

4.3.6 The effect of environmental concern

Interviewed people in firms were asked to rate their concern about the environment, such as pollution, global warming or climate change. In all case studies, they declared a high level of environmental concern (Figure 25); about 85% of respondents felt concerned or extremely concerned in the accommodation and services sectors and about 63% in the agricultural sector. However, statistically significant difference exists

between countries (Pr>Chi2(9)=0.00). Respondents of the hotel sector in Greece are much more concerned about the environment than in other countries/sectors. Respondents of the agricultural sector in Ireland are less likely to be concerned or extremely concerned about the environment. The hotel sector in Spain and the commercial sector in Ireland have a comparable degree of concern about the environment (Pr>Chi2(3)=0.55).

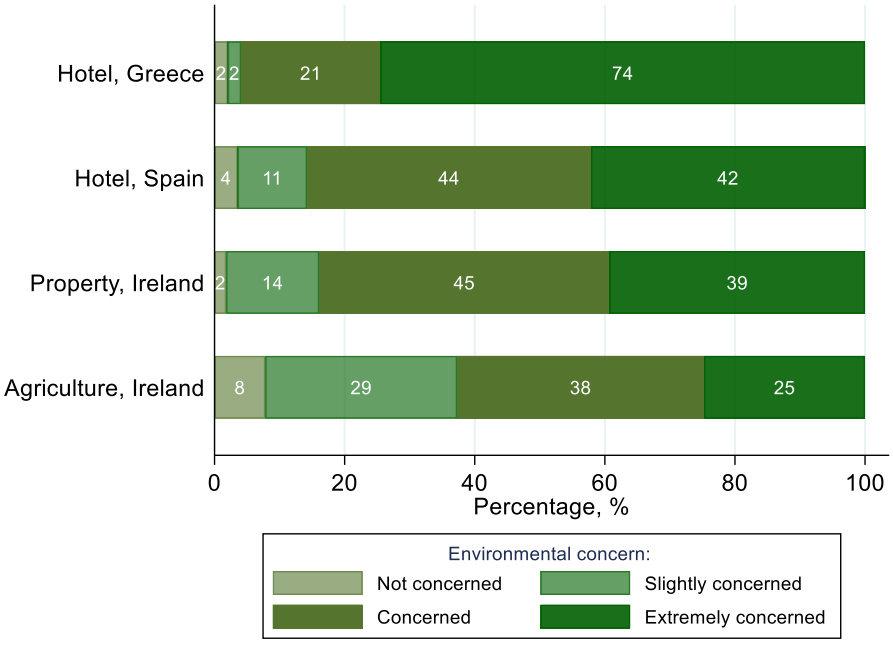


Figure 25: Degree of environmental concern in the business sector

The four levels of environmental concern were regrouped in two levels[16]: firms not or slightly concerned and firms concerned or extremely concerned. We found a significant difference of the IDR distribution in Spain; **more environmentally concerned respondents tend to have a higher discount of the future**, i.e. give lesser importance to future energy savings (Table 21, Figure 26). This counterintuitive result is observed in only one case study, however. Feedback effects of climate change concern on environmentally friendly attitudes for the household could explain this relation: consumers who already invest in EE behaviours can feel less concern about climate change. The semantic could also explain this result since in Spain a single word is used both to express concerns and worries. The negative reference made in the question "*pollution, global warming or climate change*" may reflect worries, people might be willing to prefer the present if the future environmental situation is to be worst.

[16] Keeping the four categories would imply dealing with too few observations in the two categories of the non or slightly concerned individuals.

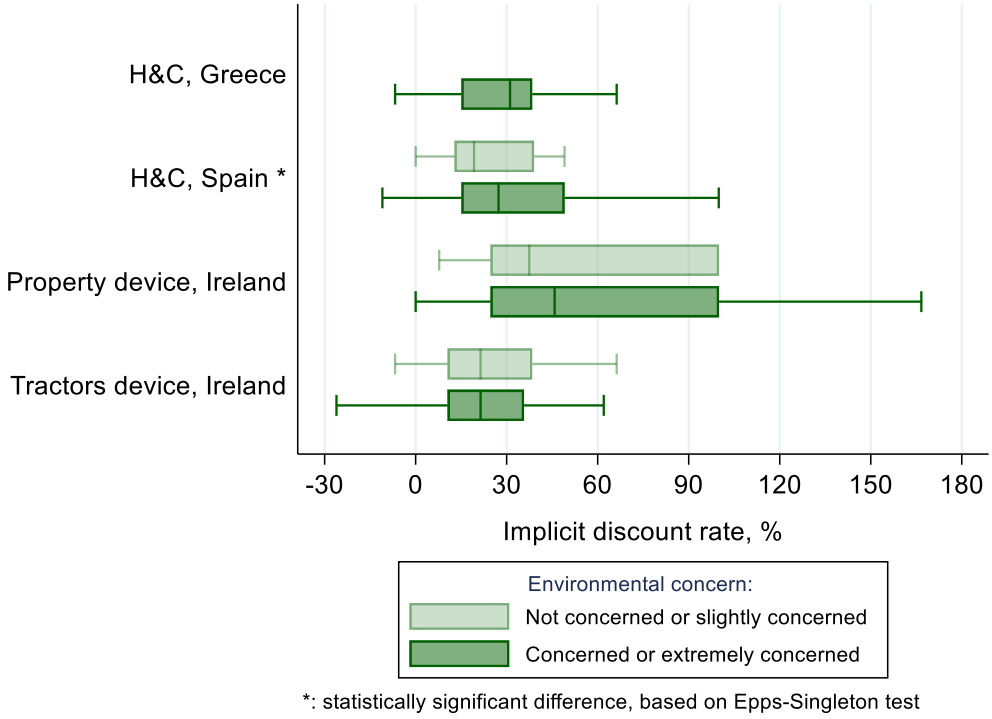


Figure 26: Environmental concern effect on the IDR per country in the business sector

Table 21: IDR statistics according to the degree of environmental concern in the business sector

		H&C, Greece	H&C, Spain***	Property device, Ireland	Tractor device, Ireland
Not or slightly concerned	Median	NA	19	37	21
	95% CI of median	[NA]	[7;48]	[25;83]	[21;29]
Concerned or very concerned	Median	31	27	46	21
	95% CI of median	[24;31]	[15;44]	[33;50]	[21;21]

*** p<0.01, ** p<0.05, * p<0.1 for Epps-Singleton test.

4.3.7 The effect of lifetime and initial costs assumptions

4.3.7.1 The effect of the initial investment cost

In each country, the survey has been implemented on three sub samples (Table 15) to test the presence of an effect of the amount of the investment cost. We tested this bias in each case study and **found no statistically significant difference of the IDR distribution**[17].

4.3.7.2 The effect of the lifetime of the good

The IDR question was designed for a given and invariant horizon of the investment in each case study. The lifetime was 10 years for heating and cooling in the accommodations sector in Greece and Spain, and for tractors in the agricultural sector in Ireland. For heating property devices in Ireland, the lifetime was 20 years. We find a statistically significant difference between the two horizons (Epps-Singleton test, Pr>z=0.000); **a longer lifetime make companies have a higher discount rate** (Figure 27 and Table 22). However, we cannot exclude that this difference is not partially due to the presence of a product effect as evidenced in Table 16.

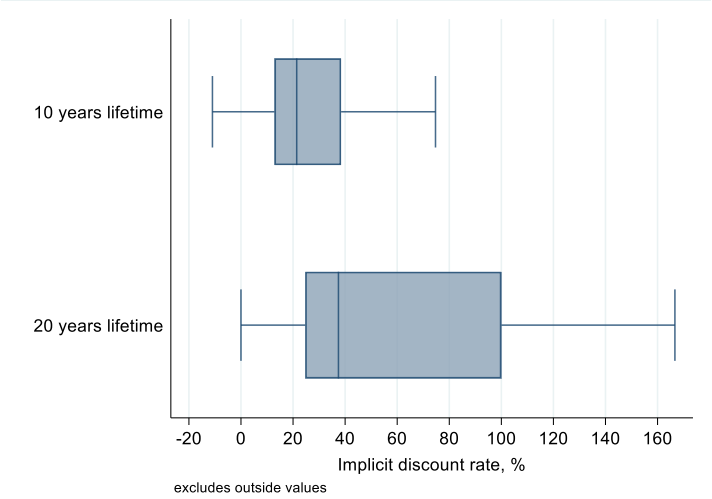


Figure 27: The distribution of the IDR by product's lifetime in the business sector

Table 22: IDR statistics according to the lifetime of the product in the business sector

Lifetime	Median	95% CI of the median	Stand. dev
10 years	21	[21;23]	29
20 years	37	[33;50]	38

[17] For H&C in Greece Pr >Chi2(2)=0.36; H&C H&C device in Spain Pr >Chi2(2)=0.21; for property heating device in Ireland Pr>Chi(2)=0.11; tractors in Ireland Pr>Chi2(2)=0.25).

5 Results from the discrete choice and field trials

Within the CONSEED project, the IDR has also been estimated using revealed preferences methods through discrete choice experiments (DCE) and field trials (FT). An IDR for both control and treatments groups is calculated. Treatment groups introduce the monetary information on energy costs or savings.

5.1 Discrete choice experiments

DCE were conducted in Norway for cars, Greece for refrigerators and Slovenia for properties in the household sector.

5.1.1 Transport goods in Norway

Willingness-to-pay (WTP) for improving fuel efficiency by one litre per 100km was NOK 83,047 in the control group, and NOK 106,710 in the treatment group who saw labels displaying annual fuel costs for the different options.

Fuel costs displayed on the labels assumed that gasoline costs NOK 15 per litre and that the cars were driven 15,000 km per year, which are typical figures for Norway. The average lifetime for cars in Norway is 18.2 years (Statistics Norway, 2018). Based on these figures, improving fuel efficiency by 1 litre per 100 km translates to annual savings of NOK 2,250.

Assuming that WTP equals the NPV of fuel cost savings and inserting the figures from above gives (see section 2.2), for the control group:

$$NOK\ 83{,}047 = \sum_{t=0}^{17.3} \frac{NOK\ 2{,}250}{(1+r)^t}$$

and for the treatment group:

$$NOK\ 106{,}710 = \sum_{t=0}^{17.3} \frac{NOK\ 2{,}250}{(1+r)^t}$$

Solving for *r* through simulation yields **IDRs of -7.1% for the control group and -9.2% for the treatment group**. Displaying additional information on estimated cost of energy use per month alongside the mandatory EU label on physical energy use makes consumer more willing to account for future costs. Given a shorter time horizon of 10 years, the discount rates would be -18.3% for the control group and -21.2% for the treatment group.

5.1.2 Properties in Slovenia

The experiment was distributed as part of wider survey undertaken in November 2017 exploring the role of EE in household investments. The WTP for EE within the treatment group was €12,794 and is significantly higher than the WTP of the control group, €8,745. This represents a 46.3% increase in the

valuation of EE when monetary estimates are included, with respect to the control group (Deliverable 4.2, CONSEED).

Assuming that WTP equals the NPV of energy savings for the improvement of the energy label for properties for one grade and inserting the numbers from above gives, for the control group:

$$€8{,}745 = \sum_{t=0}^{n} \frac{€187.54}{(1+r)^t}$$

And for the treatment group:

$$€12{,}794 = \sum_{t=0}^{n} \frac{€187.54}{(1+r)^t}$$

Results are presented in the table below.

Table 23: Implicit Discount Rates for Slovenian Properties

	Control trial	**Treatment trial**
Regression observations	226	200
Size of the property (m2)	55	55
kWh/m2/year Savings for one grade improvement on energy label (kWh/m2)	47.15	47.15
Energy savings for one grade improvement on energy label (€)	187.54	187.54
Investment Duration (years)	25	25
WTP for One Grade Improvement	8,745	12,794
95% confidence interval of WTP	[6,859; 10,631]	[10,584; 15,004]
Implicit Discount Rate for 25 Year duration	**-4.31%**	**-6.59%**
95% confidence interval	[-2.74%;-5.51%]	[-5.48%;-7.48%]
Implicit Discount Rate for 10 Year duration	**-21.26%**	**-25.17%**
95% confidence interval	[-18.55%;-23.31%]	[-23.27%;-26.71%]

Sources: Own calculations using the data from DCE survey and results from Del. 4.2

The IDR of the properties is always negative and varies between -4.3 % for the control trial and -6.59% for the treatment trial. Since there is a considerable difference, it is hard to make a simple comparison across experimental groups. When the investment duration is shortened from 25 to 10 years, the discount rate decreases significantly to less than -20%. There are probably more reasons that IDRs are negative: the general visual appearance of a property normally improves during an EE upgrade but it is difficult to capture in models; households are not aware of the cost savings associated with their EE improvements; households might expect that the electricity costs will be higher in the future and take the investment as a hedge against the risk of increasing prices in future.

5.1.3 Appliances in Greece

The Greek DCE was designed using a split sample approach, according to which the respondents were randomly assigned to one of four experimental conditions, as follows:

- a labelled experiment without additional information on the estimated cost of energy (control sample)
- a labelled experiment with additional information on the estimated cost of energy (treatment 1)
- a non-labelled experiment without additional information on the estimated cost of energy (treatment 2), and
- a non-labelled experiment with additional information on the estimated cost of energy (treatment 3).

The WTP in Euros per 1 kWh of reduced consumption for the control and the three treatment groups were €2.28, €2.21, €1.98, and €1.91, respectively. Furthermore, the cost per electrical kWh, as displayed in the DCE cards, was €0.14. Finally, three different refrigerator lifetime values were assumed, namely 7, 10 and 15 years. The first two values reflect the consumers' expectations (Ricardo-AEA. 2015, p. 6). The last value, i.e. a lifetime of 15 years, is a typical lifetime assumed for Lifecycle Cost Analyses of refrigerators (e.g. Michel et al., 2016).

The IDRs were estimated solving the equation described in Section 2.2 for *r* through simulation. Results are given in the following table and figure.

Table 24: IDRs for household appliances based on the Greek DCE

		Control Group	Treatment 1	Treatment 2	Treatment 3
7 years lifetime					
	Mean IDR	-17.5%	-17.0%	-15.0%	-14.5%
	95% CI	[-20.0%;-14.6%]	[-19.5%;-14.1%]	[-17.6%;-11.8%]	[-18.1%;-10.9%]
10 years lifetime					
	Mean IDR	-8.0%	-7.0%	-5.9%	-5.3%
	95% CI	[-10.1%;-5.5%]	[-9.6%;-5.1%]	[-8.1%;-3.1%]	[-7.6%;-2.4%]
15 years lifetime					
	Mean IDR	-1.0%	-0.6%	0.7%	1.2%
	95% CI	[-2.8%;1.0%]	[-2.3%;1.4%]	[-1.0%;3.0%]	[-0.6%;3.6%]

Sources: Own calculations

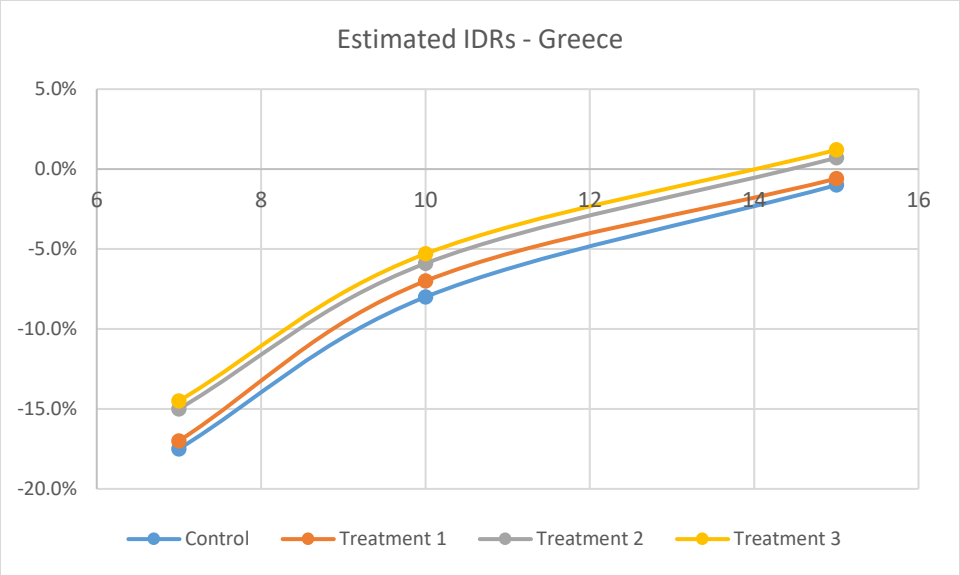


Figure 28: IDRs for household appliances based on the Greek DCE

The IDRs range from -17.5% up to 1.2%, based on the WTP and the assumed lifetime. **In general, the IDRs are low or negative**. This finding may be due to a number of factors not captured by the model per se. For instance, as found from the consumers' survey conducted in Greece (Deliverable 3.1), only 10% of the respondents provided an answer within the 'typical' range of the energy cost of a refrigerator in Greece. More than 60% of them declared that they do not know the amount of money paid to the electricity utility each year for the operation of their refrigerator, and the rest overestimated (in same cases significantly) their energy cost. The negative discount rates are not uncommon in surveys relating to EE. Heinzle (2012) argues that one explanation might be consumers' expectation that electricity costs will greatly increase in the future and, thus, the investment in an EE appliance serves as a hedge against the risk of rising energy prices. Other researchers (e.g. Espey and Nair, 2005; Gillingham *et al.*, 2009) suggest that negative discount rates might reflect economic efficiency at a societal level (e.g. consumers' WTP for reductions in greenhouse gases or other emissions from energy production).

5.2 Fields trials

5.2.1 Property in Ireland

The IDR is calculated for Irish property using data from daft.ie (pre-trial) and the Irish Property Price Register (PPR) (Table 25). Data covers the period from January 2017 to February 2018 for all counties in Ireland (pre-trial period only). All data exclusions, cleaning and merging processes are identical to those outlined in Deliverable 4.1.

Table 25: Implicit Discount Rates for Irish Property Sales (Closing Prices) based on Marginal Energy Efficiency Premium and Marginal Energy Savings

	Ireland	Dublin	Non-Dublin	1-2 Bed	3+ Bed
Regression Observations	**12,446**	**4,785**	**7,661**	**3,196**	**9,250**
Mean Price (€)	€289,306	€411,076	€213,218	€234,335	€308,295
Mean Size (m2)	115	101	127	70	131
Price Increase for One BER Improvement (%)	2.71%	1.19%	3.75%	2.80%	2.58%
Price Increase for One BER Improvement (€)	€7,841.38	€4,889.54	€7,997.26	€6,567.43	€7,968.68
kWh/m2/year ***Savings for Single BER Level Improvement***	33.75	33.75	33.75	33.75	33.75
Euro Energy ***Savings for Single BER Level Improvement***	€282.88	€248.44	€312.40	€172.19	€322.24
25 Year Discount Rate for Mean Property Characteristics	**-0.78%**	**1.93%**	**-0.18%**	**-3.02%**	**0.08%**
95% Confidence Interval - Lower	-1.43%	0.02%	-0.86%	-3.96%	-0.75%
95% Confidence Interval - Upper	-0.04%	4.77%	0.60%	-1.86%	1.07%
10 Year Discount Rate for Mean Property Characteristics	-15.24%	-10.73%	-14.24%	-19.03%	-13.79%

Sources: Own calculations using daft.ie data and the Property Price Register
Notes: Data from January 2017 to February 2018 (pre-trial). Zeros in size (25%) removed before calculating mean. Price increase is for a one unit increase in the BER, such as C2 to C1 from a regression which included property type, area controls and number of bedrooms. Energy savings based on this BER increase using average energy price and size. See Deliverable 4.1 for further details on data assumptions and processes. Confidence interval based on regression results (not shown).

Overall (all properties), the IDR is close to zero (-0.8%). Low or negative discount rates are likely due to missed variables which are correlated with EE but difficult to capture. For example, the general visual appearance of a property normally improves during an EE upgrade and would be a valued attribute for buyers. Households may also value improvements in general thermal comfort levels, which are again difficult to capture in models. It should also be noted that households are not aware of the cost savings associated with their EE improvements (highlighted in the surveys in Deliverable 3).

There are regional differences in the IDR. Table 25 shows an approximate two percentage point difference between Dublin (1.9%) and non-Dublin counties (-0.2%). There are also difference between smaller (-3%) and larger properties (0.1%). These estimates are considerably smaller than previous literature.

Unlike other trials and experiments, there are c**onsiderable differences between the control and treatment groups in Irish property** which prevent a simple comparison of IDRs across experimental groups. This is due to the inclusion of Dublin and surrounding counties in the treatment group where prices are higher and EE premiums are considerably lower.

The models employed in Deliverable 4.1 use a difference-in-differences specification which compare efficiency premium differences within groups (pre-trial versus trial). Table 26 shows the IDR for control and treatment groups before and after the trial. Deliverable 4.1 showed that control EE premiums declined

during the trial but increased for the treatment group. The IDRs reflect these changes: compared to the pre-trial period, trial IDRs are higher (less negative) for the control group but higher for the treatment group.

Table 26: Implicit Discount Rates for Irish Property Sales Pre and During Trail (Closing Prices) based on Marginal Energy Efficiency Premium and Marginal Energy Savings

	Control: Pre-Trial	**Control: Trial**	**Treatment: Pre Trial**	**Treatment: Trial**
Price Increase for One BER Improvement (%)	4.24%	3.47%	2.06%	2.14%
Price Increase for One BER Improvement (€)	€12,480.45	€10,203.53	€6,044.83	€6,283.35
kWh/m2/year Savings for One BER Improvement	33.75	33.75	33.75	33.75
Energy Savings for One BER Improvement	€282.88	€282.88	€282.88	€282.88
Investment Duration (years)	25	25	25	25
25 Year Discount Rate for Mean Property Characteristics	**-3.96%**	**-2.64%**	**1.25%**	**0.93%**

Sources: Own calculations using daft.ie data and the Property Price Register

Notes: Data from January 2017. Price increase is for a one unit increase in the BER, such as C2 to C1 from a regression which included property type, area controls and number of bedrooms. Energy savings based on this BER increase using average energy price and size. See Deliverable 4.1 for further details on data assumptions and processes.

5.2.2 Appliances in Spain

The IDR for washing machines, dishwashers and fridges has been estimated from the small retailer's field trial in the Basque Autonomous Country, Spain. The estimation is based on hedonic regressions which aimed at estimating the WTP (in €) for high EE appliances for each product category (Appendix 6.4).

The field trial was composed of a control group (from February 2018 until July 2018) and a treatment group with the following sequential treatments:

- Treatment 1 (February 5th - April 4th): A lifetime energy savings label is displayed in addition to the current EU energy label. Under this treatment, consumers could read the energy savings information in monetary units for any appliance displayed at the stores.
- Treatment 2 (April 5th - June 3rd): The sales staff provide information related to energy savings for each appliance under study.
- Treatment 3 (June 4th - July 31st): Combination of the two previous treatments

To estimate the effect of displaying additional information to the current label, we estimate the IDR for the control and the treatment groups, as in explained in section 2.2. We consider a purchase in the Treatment group as a purchase in any of the three treatments since all treatments contain a monetary information on energy savings.

The IDR for washing machines (8 kg) for control sales is: for 7 years lifetime -21.18%; for 10 years lifetime -11.14% and for 15 years lifetime -3.54%. The IDR remains negative for the three lifetime periods. In the

treatment group the level of EE resulted with no significant effect on the price (Table A 8), this would result in a zero willingness to pay for EE which prevents to compute an IDR. It is to notice that washing machines (8kg) labelled as A+++ entails 99% of washing machines sold during the control period and 98% during the treatment period.

Table 27: Implicit Discount Rates for Spanish appliances estimated in the field trials

	CONTROL			TREATMENT		
	Dishwasher (450mm)	**Dishwasher (600mm)**	**Fridge**	**Dishwasher (450mm)**	**Dishwasher (600mm)**	**Fridge**
Regression observations	65	135	346	63	194	628
Mean price (€)	443.79€	467.03€	607.47€	419.81€	524.85€	644.86€
Price Increase for improvement in the EE level (%)	19.25%	25.98%	14.23%	34.79%	43.70%	22.95%
Price Increase improvement in the EE level (€)	85.45€	121.36€	86.49€	146.05€	229.35€	148.03€
Annual energy Savings for improvement in the EE level (€/year)*	7.35€	7.34€	12.87€	6.31€	7.25€	12.77€
Investment Duration (years)	7	7	7	7	7	7
Implicit Discount rate	**-11.28%**	**-17.97%**	**1.03%**	**-20.86%**	**-27.65%**	**-11.07%**
Confidence interval (95%)	(-23.9%; NA)	(-24.1%; -4.8%)	(-10.4%; 38.5%)	(-31.9%; NA)	(-33.2%; -15.3%)	(-19.3%; 9.3%)
Investment Duration (years)	10	10	10	10	10	10
Implicit Discount rate	**-2.64%**	**-8.23%**	**7.96%**	**-10.86%**	**-16.70%**	**-2.46%**
Confidence interval (95%)	(-13.4%; NA)	(-13.7%; 2.9%)	(-1.9%; 41.6%)	(-30.4%; NA)	(-21.6%; -6.1%)	(-9.5%;15.6%)
Investment Duration (years)	15	15	15	15	15	15
Implicit Discount rate	**5.22%**	**-1.19%**	**12.25%**	**-3.33%**	**-8.02%**	**3.51%**
Confidence interval (95%)	(-5.4%; NA)	(-5.6%; 8%)	(4.%;42.7%)	(-11%; NA)	(-11.9%; 0.5%)	(-2.3%;18.9)

NA: IDR could not be computed for that boundary value.
*: Price of electricity used: 0,182€/kWh

The estimation of the IDR is presented in Table 27 for the control and treatment groups. In the particular case of dishwashers (450mm) during control period, it could be seen that a positive IDR is obtained for 15 years lifetime while the IDR for the same lifetime for treatment period is negative. Similar results are

obtained for 600mm dishwashers. While the IDR for these dishwashers during control period is negative (-8.23%), the IDR during treatment period is even more negative (-16.70%). In the case of the fridges under control stores, positive IDR was obtained for all the lifetimes (7 years lifetime, 10 years lifetime and 15 years lifetime). For 15 years lifetime, both in control period and in treatment period IDR is positive.

Overall, IDRs are higher during control period than during treatment period, and the display of monetary information makes people more willing to value future energy savings they can realize when buying EE appliances if they are informed about those future savings.

6 Discussion and Conclusion

This report has estimated the **implicit discount rate** (IDR) in the household and the business sectors, across different products and different product categories, with different initial investment costs and different lifetime, and has tested the effect of some socio-economic and behavioural factors that could influence the IDR. The IDRs have been estimated with three methodologies: using a direct question in a consumer survey and using valuation method (DCEs) and field trial. Knowing the IDR of consumers is highly relevant since consumers with high discount rates are less likely to invest in EE goods (Newell and Siikamäki, 2015); the profitability of such investment depends on the rate at which consumers discount future energy savings.

The direct question in the **consumer survey** is a question asking respondents to return an **internal rate of return** on the purchase of an energy-related good. It consisted in asking them to return a monetary amount of energy saving they would expect over a period of time in order to buy an energy efficient good at a given cost. This question followed the same structure in all case studies and varies with the product, its lifetime and the initial investment costs.

The **willingness/ability to answer** the question varies across products and sectors. For transport goods (cars, tractors) in the household sector and appliances (heating and cooling system) in the business sector, the majority of the respondents did not return any amount of energy savings. The main reason invoked was they did not know how to calculate savings. For the other goods, the non-answers represent up to one third of the sample (Figure 29). For property device, the landlord-tenant problem occurring when the tenant is not responsible of the investment costs but will receive its benefits, was cited as a reason for not answering.

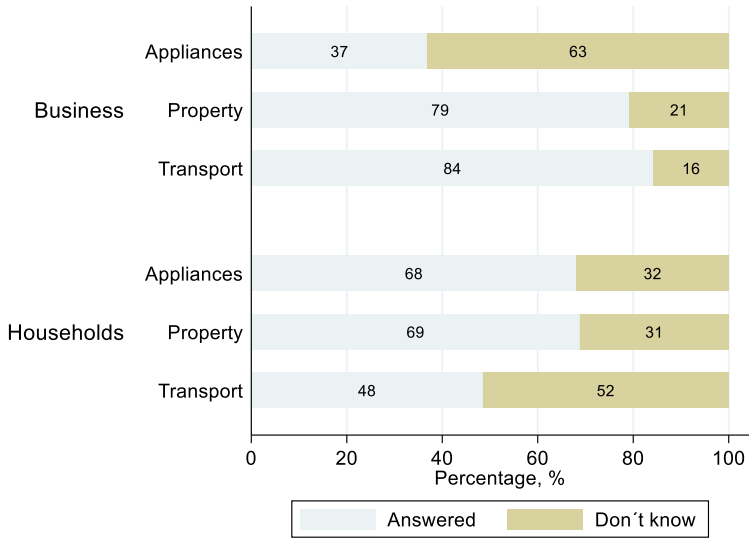


Figure 29: Rate of answers and "Don´t knows" in the household and business sector by product category

The **distribution of the IDR** varies between products, not by sectors. We did not find a statistically significant difference in Ireland for property devices between the two sectors (Pr >z=0.15). The median IDR varies from 6% for household cars in Norway to 37% for commercial property devices in Ireland (Figure 30, Table 28). Winer (1997) also found that consumers cannot have a unique IDR.

Negative IDRs have been observed. A negative IDR corresponds to those people willing to invest in a good with negative returns. Altruistic behaviours, strategic commercial behaviours for firms and coverage against future energy price volatility can all explain why the investment would be made even if the direct returns are negative. These cases occurred more in the household sector (17% of respondents) than in the business sector (6.5% of respondents).

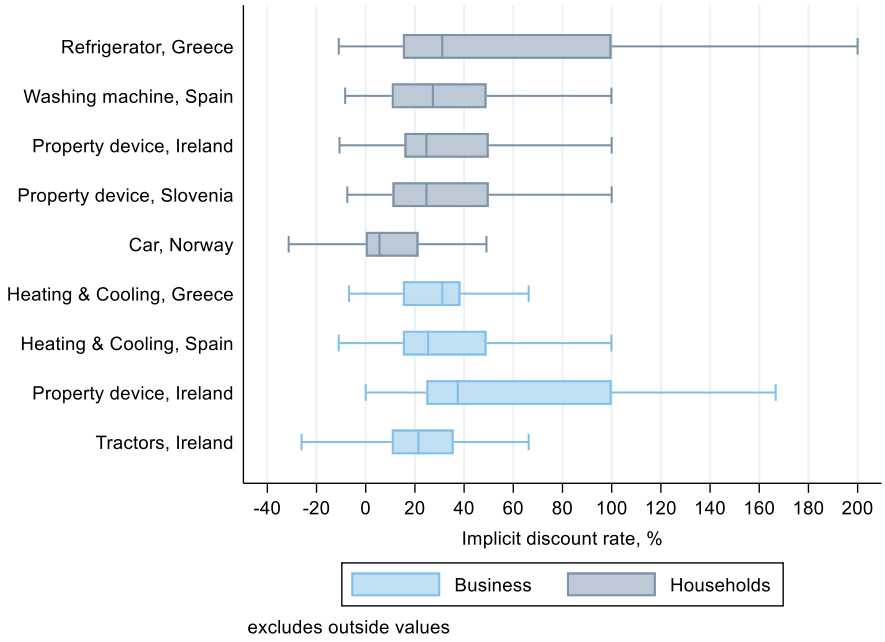


Figure 30: The IDR distributions in the household and business sectors

In the household sector, we observed no **country effect** in case studies analysing the same product. This enabled us to test a product effect – a difference in IDR distribution for goods of the same category (ex. refrigerator and washing machine in the appliances category) given that the goods of the same category were analysed in different countries. We found a product effect. **Similar results were found in the business sector: no country effect is detected but a product effect prevail.**

Table 28: Summary statistics for the IDR distribution in the household and business sectors

Sector		Number of observations	Mean	Median	95% binomial CI of the median	Standard. Deviation.
Households	Refrigerator, Greece	314	62	31	[27;38]	76
	Washing machine, Spain	340	37	27	[20;31]	37
	Property device, Ireland	322	41	25	[25;25]	39
	Property device, Slovenia	289	36	25	[25,25]	37
	Car, Norway	516	22	6	[4;8]	44
Business	Heating and cooling, Greece	35	35	31	[24;31]	28
	Heating and cooling, Spain	74	35	25	[15;38]	31
	Property device, Ireland	133	55	37	[33;50]	38
	Tractors device, Ireland	252	29	21	[21;21]	28

Table 29: Summary of the factors influencing the IDR in the household and business sectors

Household sector							
Factors	Refrigerator	Washing machine	Heating control device	Heating control device	Car	Pooled sample	Level of certainty†
	Greece	Spain	Ireland	Slovenia	Norway		
	Appliances		Property		Transport		
Sector	✓		✓		✓	Difference	***
Country effect	-	-	✓	✓		No difference	***
Product effect	✓	✓	-	-	-	Difference	***
Case study effect	✓	✓	✓	✓	✓	Difference	***
Gender (women)	NS	NS	NS	Positive***	Positive*	-	2/5
Income/Finance	NS	Negative***	NS	NS	NS	-	1/5
Label awareness	NS	Negative***	NS	Negative**	NS	-	2/5
Environmental concern	NS	Positive**	NS	NS	Positive**	-	2/5
Initial investment cost	NS	Negative***	NS	Negative***	Negative***		3/5
Product lifetime	✓	✓	✓	✓	✓	Positive	***

Business sector						
Factors	Heating and cooling	Heating and cooling	Heating Property device	Tractors	Pooled sample	Level of certainty†
	Greece	Spain	Ireland			
	Appliances		Property	Transport		
Sector	✓		✓	✓	Difference	***
Country effect	✓	✓	-	-	No-difference	***
Product effect	-	-	✓	✓	Difference	***
Case study effect	✓	✓	✓	✓	Difference	***
Gender (women)	NA	-	-	NA	-	NA
Income/Finance	NS	NS	Negative*	NS	-	1/3
Label awareness	NS	Positive***	Negative*▪	-	-	1/3
Environmental concern	-	Positive***	NS	NS	-	1/3
Initial investment cost	NS	NS	NS	NS	-	0/4
Product lifetime	✓	✓	✓	✓	Positive	***

Significance of the tests: *** p<0.01, ** p<0.05, * p<0.1

NS stands for Non-significant. NA stands for Not Applicable (due to lack of observations)

†: It indicates either the level frequency or level of confidence when indicated with stars in which the factor has a statistically significant effects in the IDR distribution. It is used to reflect the certainty of the results.

▪: small sample size (<10)

✓: Indicates the case studies involved in the test done with the pooled sample.

Gender has also an influence on the IDR: women expect a higher return (energy savings) on the investment and thus tend to discount the future more than men. This result was found in 3 of the 5 case studies. A similar result is found in the literature (Bruderer Enzler et al., 2014). The **label awareness** is an effective instrument in reducing the IDR and makes people more aware of the future flow of energy savings, in 2 of the 5 case studies. The household's **financial situation** influences the IDR; households living more comfortably on their current income discount the future less. This result was found in 1 of the 5 case studies. Similar results were found in Hausmann (1979), Houston (1983) or Min (2014).

The level of **environmental concern** also has an influence; it has been found, in 1 of the 5 case studies, that it increases the IDR and thus increases the discount rate. Such a behaviour may seem counterintuitive as one could expect more environmentally concerned to discount less the future, i.e. to give more importance to reducing future CO_2 emissions associated to their own energy consumption. This behaviour may be explained by the feedback effect from mitigation behaviours (Sandvik, 2008; van der Linden, 2017); households taking energy mitigating actions can have less concern about the environment (Table 29). However, this is found in a minority of our case studies.

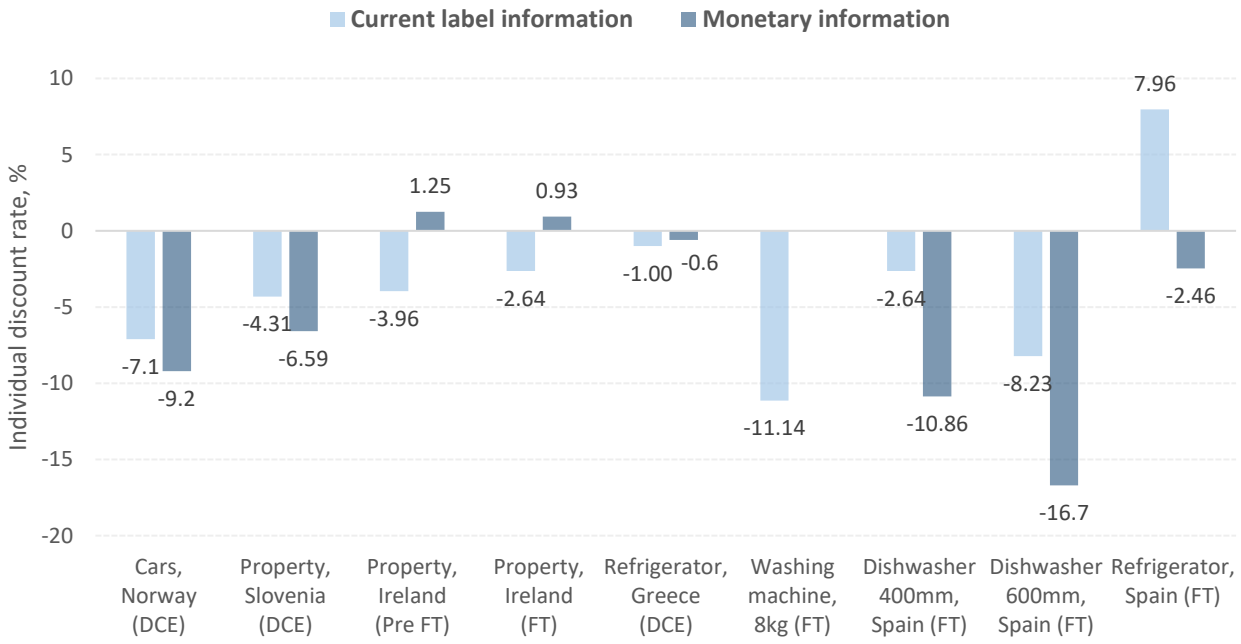
An anchoring effect has been found in our sample; the level of the **initial investment cost** asked in the discounting question influences the amount of savings. The higher the investment, the smaller the discount rate. Households tend thus to expect lower returns from large investment and therefore tend to discount the future less when the investment cost is large. Similar result is obtained in Benzion et al. (1989).

The **lifetime of the product** influences the IDR distribution; when facing products with a longer lifetime, households and firms of the business sector give less importance to future flows of savings (they have a higher discount rate). The effect of time horizon has largely been studied to test the time invariant assumption of the discount factor in the discounted utility model (Frederick et al., 2002). Several studies observed a hyperbolic discounting, that is to say that the discount rate decreases as the time horizon increases: people give lower importance to future monetary flows when they are received in a longer time horizon than when they are received in a shorter time horizon. However such a relation has been found for small delays (< 1 year). For larger time horizons, the relation is not demonstrated (Frederick et al., 2002).

An average implicit discount rate has been estimated with data from **discrete choice experiments (DCE) and field trials (FT)** conducted in the CONSEED. We found a noticeable difference between the methods of econometric estimations of the IDR (in the DCE and FT) and the survey question. However, the two methodologies are not directly comparable: the IDR in the survey question is elicited individually while for DCE and FT the IDR is an average IDR resulting from a regression analysis estimating the willingness to pay for energy efficiency improvement. In the survey question, no reference was made to any attributes different from energy efficiency and duration. In discrete choice experiments, a set of attributes was presented in the choice cards including energy efficiency. Respondents are thus making an arbitrage between different attributes to choose their preferred option. These additional attributes that influence the choice cannot be controlled for in the survey question and we cannot exclude respondent to overestimate the IDR. Also, the good for which the IDR is estimated differs between case studies and methods which

limits comparability. In Ireland, the survey question measured the IDR of a heating property device while in the field trial the IDR of an energy efficient property is measured.

The main result from the IDR estimation in the FT and DCE is on the role of providing additional monetary information: **consumers are more likely to reduce their discount rate if they know the future amount of savings or energy costs**. This result was found in five out of the eight products tested (Figure 31). In these particular cases, the average IDR is often negative: consumers are willing to pay more than what they will receive from energy savings during the lifetime of the good. The monetary information reinforces this attitude.



FT: field trial / DCE: discrete choice experiment

Figure 31: Average IDR estimated in field trials (FT) and discrete choice experiments (DCE). Lifetime used: 18.2 years for cars, 25 years for property, 15 years for refrigerators and 10 years for dishwasher and refrigerator in Spain.

References

CONSEED references:

Deliverable 1.1. 2017 Understanding consumer decision making in the context of energy efficiency. CONSEED project https://www.conseedproject.eu/wp1

Deliverable 3.1. 2018. Consumer's energy efficiency choices for different consumer groups and geographical locations: survey results. CONSEED project https://www.conseedproject.eu/wp3

Deliverable 4.1. 2019. Report in field trial evidence on the effectiveness of providing information on energy costs on energy related decision in households. CONSEED project: https://www.conseedproject.eu/wp4

Deliverable 4.2. 2018. Report on choice experiments on the effectiveness of providing information on energy costs on energy related decisions in households. CONSEED project: https://www.conseedproject.eu/wp4

Other references

Benzion, U., Rapoport, A., Yagil, J., 1989. Discount Rates Inferred from Decisions: An Experimental Study. Manag. Sci. 35, 270–284.

Bruderer Enzler, H., Diekmann, A., Meyer, R., 2014. Subjective discount rates in the general population and their predictive power for energy saving behavior. Energy Policy 65, 524–540. https://doi.org/10.1016/j.enpol.2013.10.049

Carson, R.T., Roth Tran, B., 2009. Discounting behavior and environmental decisions. J. Neurosci. Psychol. Econ. 2, 112–130. https://doi.org/10.1037/a0017685

Dietz, T., 2015. Altruism, self-interest, and energy consumption. Proc. Natl. Acad. Sci. 112, 1654–1655. https://doi.org/10.1073/pnas.1423686112

Dieu-Hang, T., Grafton, R.Q., Martinez-Espineira, R., Garcia-Valinas, M., 2017. Household adoption of energy and water-efficient appliances: An analysis of attitudes, labelling and complementary green behaviours in selected OECD countries. J. Environ. Manage. 197, 140–150. https://doi.org/10.1016/j.jenvman.2017.03.070

Epps, T.W., Singleton, K.J., 1986. An omnibus test for the two-sample problem using the empirical characteristic function. J. Stat. Comput. Simul. 26, 177–203. https://doi.org/10.1080/00949658608810963

Espey, M., Nair, S., 2005. Automobile Fuel Economy: What Is It Worth? Contemp. Econ. Policy 23, 317–323. https://doi.org/10.1093/cep/byi024

Frederick, S., Loewenstein, G., O'Donoghue, T., 2002. Time Discounting and Time Preference: A Critical Review. J. Econ. Lit. 40, 351–401. https://doi.org/10.1257/002205102320161311

Gillingham, K., Newell, R.G., Palmer, K., 2009. Energy Efficiency Economics and Policy. Annu. Rev. Resour. Econ. 1, 597–620. https://doi.org/10.1146/annurev.resource.102308.124234

Hausman, J.A., 1979. Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables. Bell J. Econ. 10, 33–54.

Heinzle, S., 2012. Consumer Response to Energy Labels -Insights from Choice Experiments. Doctoral dissertation at University of St. Gallen. Available from: https://www1.unisg.ch/www/edis.nsf/SysLkpByIdentifier/4020/$FILE/dis4020.pdf.

Houston, D.A., 1983. Implicit Discount Rates and the Purchase of Untried, Energy-Saving Durable Goods. J. Consum. Res. 10, 236–246. https://doi.org/10.1086/208962

Issock, P.B.I., Mpinganjira, M., Roberts-Lombard, M., 2018. Drivers of consumer attention to mandatory energy-efficiency labels affixed to home appliances: An emerging market perspective. J. Clean. Prod. 204, 672–684. https://doi.org/10.1016/j.jclepro.2018.08.299

McFadden, D., 1974. The measurement of urban travel demand. J. Public Econ. 3, 303–328. https://doi.org/10.1016/0047-2727(74)90003-6

Min, J., Azevedo, I.L., Michalek, J., de Bruin, W.B., 2014. Labeling energy cost on light bulbs lowers implicit discount rates. Ecol. Econ. 97, 42–50. https://doi.org/10.1016/j.ecolecon.2013.10.015

Newell, R.G., Siikamäki, J., 2015. Individual Time Preferences and Energy Efficiency. Am. Econ. Rev. 105, 196–200. https://doi.org/10.1257/aer.p20151010

Nguyen, T.N., Lobo, A., Greenland, S., 2017. Energy efficient household appliances in emerging markets: the influence of consumers' values and knowledge on their attitudes and purchase behaviour. Int. J. Consum. Stud. 41, 167–177. https://doi.org/10.1111/ijcs.12323

OECD, 2014. Greening Housheold Behaviour: Overview from the 2011 survey - Revised edition, OECD Publishing. ed, OECD Studies on Environmental Policy and Household Behaviour.

Rosen, S., 1974. Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition. J. Polit. Econ. 82, 34–55. https://doi.org/10.1086/260169

Samuelson, P.A., 1937. A Note on Measurement of Utility. Rev. Econ. Stud. 4, 155. https://doi.org/10.2307/2967612

Sandvik, H., 2008. Public concern over global warming correlates negatively with national wealth. Clim. Change 90, 333–341. https://doi.org/10.1007/s10584-008-9429-6

Spiliotopoulos, C., Stamminger, R., Siderius, H.-P., 2019. Bringing the home in the lab: consumer-relevant testing for household electrical products. Energy Effic. 12, 281–298. https://doi.org/10.1007/s12053-018-9718-5

Statistics Norway, 2018. Registrerte personbiler, etter bilens alder og fabrikkmerke. Gjennomsnittsalder på registrerte personbiler, 2017. Available from: https://www.ssb.no/transport-og-reiseliv/statistikker/bilreg/aar Last access 14.03.2019.

Train, K., 1985. Discount rates in consumers' energy-related decisions: A review of the literature. Energy 10, 1243–1253. https://doi.org/10.1016/0360-5442(85)90135-5

Tversky, A., Kahneman, D., 1974. Judgment under Uncertainty: Heuristics and Biases. Science 185, 1124–1131. https://doi.org/10.1126/science.185.4157.1124

van der Linden, S., 2017. Determinants and Measurement of Climate Change Risk Perception, Worry, and Concern (SSRN Scholarly Paper No. ID 2953631). Social Science Research Network, Rochester, NY.

Winer, R., 1997. Discounting and Its Impact on Durables Buying Decisions. Mark. Lett. 8, 109–118. https://doi.org/10.1023/A:1007945629536

Appendices

6.1 The Implicit discount rate questions

Table A 1: The IDR questions per case study for the households and the business sectors

Sector	Sector	Country	Question
Households	Property	Ireland	Imagine that you have the option of installing new advanced heating controls which will reduce your household's heating costs. The controls are an add-on to your existing system and will cost €400/€600/€800, including installation (which takes about 15 minutes). The controls will last for 20 years, but if you move, you can easily reinstall them in your new house. In order for you to commit to this €400/€600/€800 investment, what is the minimum you would need to save on heating costs per year?
Households	Appliances	Greece	Let us assume that you contemplate buying a new refrigerator which will last for 10 years. You have the option to choose between two models of the same brand and same characteristics but differing only in relation to their energy consumption and purchase price. The energy efficient model costs {50, 100, 150} € more but leads to reduced energy bills in the future. How much money in your energy bill would you like to save yearly for the next 10 years in order to find it worth paying the extra purchase cost of {50; 100; 150} € for the energy efficient model?
Households	Appliances	Spain	Suppose you could buy and install a new washing machine that will last for the next 10 years and you can decide between two models whose unique distinction relies on their energy efficiency level (energy consumption): a standard one and an efficient one that costs {50;100; 150} € more but can generate a reduction in your future electricity bills. How much would you have to save in your electricity bill approximately per year during the next 10 years in order to pay for the additional {50;100; 150} €?
Households	Property	Slovenia	Imagine that you have the option of installing new advanced heating controls which will reduce your household's heating costs. The controls are an add-on to your existing system and will cost €400/€600/€800, including installation (which takes about 15 minutes). The controls will last for 20 years, but if you move, you can easily reinstall them in your new house. In order for you to commit to this €400/€600/€800 investment, what is the minimum you would need to save on heating costs per year?
Households	Transport	Norway	Suppose you could buy a new car that you will keep for the next 10 years and you can decide between two models whose unique distinction relies on their fuel consumption: a standard one and an efficient one that uses considerably less fuel and costs NOK {20,000; 40,000; 60,000} more but can generate a reduction in your future electricity bills. How much would you have to save in your electricity bill approximately per year during the next 10 years in order to pay for the additional NOK {20,000; 40,000; 60,000}?
Business	Services	Ireland	Imagine that you have the option of installing new advanced heating controls which will reduce your business's heating costs. The controls are an add-on to your existing system and will cost €400/€600/€800, including installation (which takes about 15 minutes). The controls will last for 20 years, but if you move, you can easily reinstall them in your new premises. In order for you to commit to this €400/€600/€800 investment, what is the minimum you would need to save on heating costs per year?

Business	Agriculture	Ireland	Imagine that your tractor dealership has contacted you about installing a device which will reduce your tractor's diesel consumption. The device is an add-on to your existing tractor engine and will cost €2,000/€3,000/€4,000, including the cost of installation (which takes about thirty minutes). The device will last for ten years, but if you sell the tractor, you can easily reinstall it on another. In order for you to commit to this €2,000/€3,000/€4,000 investment, what is the minimum you would need to save on diesel costs per year?
Business	Appliances	Spain	Suppose you could install an additional smart device for your heating and cooling system, which would allow you to reduce your lodging's energy bill. This device will be used for the next 10 years and costs around €200/€250/€300 more per room. How much would you have to save in your energy bill approximately per year and per room during the next 10 years in order to pay for the additional €200/€250/€300?
Business	Appliances	Greece	Suppose you could buy and install a new energy-efficient cooling / heating system that will last for the next 10 years. You can decide between two models whose unique distinction relies on their energy efficiency level (energy consumption): a standard one and a more efficient one that costs {500; 1,000; 1,500} € more but can generate a reduction in your future electricity bills. How much would you have to save in your electricity bill approximately per year during the next 10 years in order to pay for the additional {500; 1,000; 1,500} €?

6.2 Tests and regressions from household sector surveys

Table A 2: Tests of country and product comparability in the Household sector

	Pr>Z	Decision	Test
H0: IDR distribution (Ireland) = IDR distribution (Slovenia)	0.143	Do not reject H0	Epps-Singleton
H0: Medians are not different between Ireland and Slovenia	0.398	Do not reject H0	Pearson chi2
H0: IDR distribution (Refrigerator) = IDR distribution (Washing machine)	0.0000	Reject H0	Epps-Singleton
H0: Median are not different between washing machine and refrigerator	0.191	Do not reject H0	Pearson chi2
H0: ability/willingness to answer in Ireland and Slovenia are independent	0.316	Do not reject H0	Chi2
H0: ability/willingness to answer in for refrigerator and washing machine are independent	0.155	Do not reject H0	Chi2

Table A 3: Test of independence of The Don´t Knows and other variables

	Test statistic, z	Pr>Z	Decision	Test
H0: Don´t Know are independent of the product category (appliances, property device, transport)	113.29	0.000	Reject H0	Chi2
H0: Don´t Know are independent of the energy source (electric and fuel)	113.20	0.000	Reject H0	Chi2
H0: Don´t Know are independent of the product type within electric category (appliances, property device)	0.099	0.753	Do not reject H0	Chi2

Table A 4: Probit models explaining the willingness/ability to answer the discounting question in the household sector

	Marginal effects†	
	Model 1	**Model 2**
Technology		
Appliances	*Reference*	-
Property device	0.017	-
	(0.023)	
Transport	-0.213***	-
	(0.037)	
Initial investment cost of energy efficient good		
Appliances+ - 50 €	-	*Reference*
Appliances+ - 100 €	-	0.018
		(0.037)
Appliances+ - 150 €	-	0.036
		(0.037)
Property device - 400 €	-	0.044
		(0.040)
Property device - 600 €	-	0.021
		(0.039)
Property device - 800 €	-	0.038
		(0.035)
Transport – 2,800 €	-	-0.250***
		(0.041)
Transport – 5,600 €	-	-0.169***
		(0.047)
Transport – 8,400 €	-	-0.163***
		(0.046)

Beliefs, behaviours and awareness		
Belief that all good have the same energy efficiency levels (=1 if strongly agree)	-0.134***	-0.132***
	(0.033)	(0.040)
Take a chance on new technologies to reduce energy consumption (=1 if strongly agree)	0.033***	0.031
	(0.023)	(0.022)
Good understanding of energy consumption of the good (=1 if strongly agree)	0.090***	0.090***
	(0.023)	(0.028)
Being aware of energy prices (=1 if strongly agree)	0.095***	0.096***
	(0.022)	(0.024)
Being aware of the energy label (=1 if strongly agree)	0.113***	0.115***
	(0.022)	(0.025)
Socio demographics		
Education		
None or Primary	*Reference*	
Secondary	0.028	0.029
	(0.067)	(0.075)
Lower degree, university	0.110**	0.110
	(0.064)	(0.069)
Higher degree, Masters	0.181***	0.181**
	(0.068)	(0.074)
Age	-0.002**	-0.002**
	(0.001)	(0.001)
Female	-0.120***	-0.121***
	(0.022)	(0.021)
Income description		
Finding it difficult or very difficult to live on current income	*Reference*	
Coping on current income	0.055*	0.054*
	(0.030)	(0.030)
Living comfortably or very comfortably on current income	0.066**	0.063**
	(0.028)	(0.028)
Observations	2,279	2,279
Wald chi2(20)	242.89	274.07
Prob > chi2	0.000	0.000
Pseudo R2	0.0838	0.0857
Log likelihood	-1337.92	-1335.16

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

†: The marginal effect for a dummy variable is the change in probability for a discrete change from zero to one. For a continuous variable, it represents the change in probability for a change of 1 unit.

+: For appliances the value represents the additional cost of buying a more energy efficient good.

Table A 5: Probit models explaining the probability of having a negative IDR in the household sector

	Marginal effects[†]
Technology	
Property device	Reference
Appliances	0.085***
	(0.015)
Transport	0.318***
	(0.035)
Purchases attributes	
Energy efficiency (=1 if important or very important attribute)	0.067***
	(0.024)
Price (=1 if important or very important attribute)	-0.166***
	(0.060)
Beliefs, behaviours and awareness	
Degree of environmental concern (=1 if extremely concerned)	0.013
	(0.020)
Buying a more energy efficient good would reduce my household's environmental impact (=1 if strongly agree)	-0.007
	(0.021)
Good understanding of energy consumption of the good (=1 if strongly agree)	0.030
	(0.023)
Being aware of the energy label (=1 if strongly agree)	0.049**
	(0.023)
Socio demographics	
Age	0.001
	(0.001)
Female	0.001
	(0.017)
Income description	
Finding it difficult or very difficult to live on current income	reference
Coping on current income	0.006
	(0.026)
Living comfortably or very comfortably on current income	0.017
	(0.028)
Observations	1,632
Wald chi2	260.14
Prob > chi2	0.000
Pseudo R squared	0.1275

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

†: The marginal effect for a dummy variable is the change in probability for a discrete change from zero to one. For a continuous variable, it represents the change in probability for a change of 1 unit.

6.3 Tests and regressions from business sector surveys

Table A 6: Tests of country and product comparability in the business sector

	Pr>Z	Decision	Test
H0: IDR(Greece) = IDR(Spain)	0.591	Do not reject H0	Epps-Singleton
H0: Median are not different between Greece and Spain	0.843	Do not reject H0	Pearson chi2
H0: IDR(tractors) = IDR(property device), both in Ireland	0.000	Reject H0	Epps-Singleton
H0: Median are not different between tractors and property device	0.000	Reject H0	Pearson chi2
H0: ability/willingness to answer in Greece and Spain are independent	0.757	Do not reject H0	Chi2
H0: ability/willingness to answer in for tractors and property device are independent	0.163	Do not reject H0	Chi2

Table A 7: Probit models explaining the willingness/ability to answer the discounting question in the business sector

	Marginal effects†	
	Model 1	**Model 2**
Technology		
Appliances	*Reference*	
Property device	0.443***	0.381***
	(0.052)	(0.058)
Transport	0.523***	NA
	(0.043)	
Beliefs, behaviours and awareness		
Belief that all good have the same energy efficiency levels (=1 if strongly agree)	0.016	0.086
	(0.061)	(0.079)
Take a chance on new technologies to reduce energy consumption (=1 if strongly agree)	0.087***	0.110
	(0.047)	(0.061)
Good understanding of energy consumption of the good (=1 if strongly agree)	0.030	-0.033
	(0.048)	(0.097)
Being aware of energy prices (=1 if strongly agree)	-0.029	-0.082
	(0.055)	(0.098)
Being aware of the energy label (=1 if strongly agree)	-	0.149***
		(0.067)
Environmental concern (=1 if concerned or extremely concerned by the environment	0.128**	0.150**
	(0.058)	(0.072)
Observations	661	395
Wald chi2(6)	149.08	64.69
Prob > chi2	0.000	0.000
Pseudo R2	0.1781	0.1430
Log likelihood	-347.29	-233.31

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
†: The marginal effect for a dummy variable is the change in probability for a discrete change from zero to one. For a continuous variable, it represents the change in probability for a change of 1 unit.

6.4 Hedonic regressions from the Spanish field trials

Table A 8: Hedonic regressions for 8kgs washing machines for the field trial (Spain) during control and treatment periods

	Control	**Treatment**
	Coef.	Coef.
efficiency	0.384**	0.219
	(0.156)	(0.170)
water_consumption	-0.001	-0.001***
	(0.001)	(0.001)
embedding	-0.337***	-0.615***
	(0.052)	(0.135)
constant	6.475***	8.377***
	(0.306)	(0.376)
Number of observations	276	489
F (3, 272)	17.29	24.45
Prob > F	0.000	0.000
R-squared	0.160	0.131
Adj R-squared	0.151	0.126
Root MSE	0.219	0.534
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
Dependent variable: log(price)		

Table A 9:Hedonic regressions for dishwashers (450mm) for the field trial (Spain) during control and treatment periods

	Control	**Treatment**
	Coef.	Coef.
efficiency	0.193*	0.348*
	(0.103)	(0.202)
services	-0.177***	0.013
	(0.044)	(0.113)
water_consumption	-0.001	-0.001*
	(0.001)	(0.001)
embedding	0.006	-0.130
	(0.049)	(0.119)
constant	8.015***	6.890***
	(0.481)	1.092
Number of observations	65	63
F (4, 60)	6.24	2.74
Prob > F	0.000	0.037
R-squared	0.294	0.159
Adj R-squared	0.246	0.101
Root MSE	0.189	0.399
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
Dependent variable: log(price)		

Table A 10: Hedonic regressions for dishwashers (600mm) for the field trial (Spain) during control and treatment periods.

	Control.	**Treatment**
efficiency	0.260***	0.437***
	(0.063)	(0.119)
services	0.061**	0.101*
	(0.025)	(0.053)
water_consumption	-0.001***	-0.001*
	(0.001)	(0.001)
embedding	-0.072	0.046
	(0.047)	(0.086)
_cons	6.005***	5.270***
	(0.382)	(0.734)
Number of observations	135	192
F (4, 130)	12.04	7.95
Prob > F	0.000	0.000
R-squared	0.270	0.145
Adj R-squared	0.248	0.1271
Root MSE	0.228	0.555
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
Dependent variable: log(price)		

Table A 11: Hedonic regressions for fridges for the field trial (Spain) during control and treatment periods.

	Control.	**Treatment**
efficiency	0.142***	0.230***
	(0.047)	(0.067)
height	-0.001	-0.001***
	(0.001)	(0.001)
refrigerator_volume	0.004***	0.005***
	(0.001)	(0.001)
freezer_volume	-0.002	0.003
	(0.001)	(0.003)
fridge_type	-0.547***	-0.381***
	(0.073)	(0.104)
embedding	-0.186***	-0.537***
	(0.070)	(0.102)
constant	6.571***	6.011***
	(0.355)	(0.270)
Number of observations	346	548
F (6, 339)	71.65	53.56
Prob > F	0.000	0.000
R-squared	0.556	0.373
Adj R-squared	0.551	0.366
Root MSE	0.226	0.506
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		
Dependent variable: log(price)		