

## **Behind the scene: Why are energy efficient home appliances such a hard sell?**

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### **Abstract**

This paper wishes to add to the rich literature of studies exploring the reasons behind the energy efficiency gap. To this aim, it presents the results of a survey conducted on a representative sample of Greek households via computer-assisted web interviewing (CAWI) in the context of the “Consumer Energy Efficiency Decision making (CONSEED)” project. The survey was designed and conducted so as to reach every type of household and gather information on the factors influencing households’ energy efficiency choices. The findings of the survey are not an end-to-itself but a vehicle for behavioural research in energy efficient decisions. The data collected and analysed can be used to populate theoretical models regarding energy efficiency gap and determine the degree to which each factor contributes to the phenomenon. Moreover, they could help decision-makers in better understand the energy paradox, and, thus, could contribute to crafting better public policy responses that would maximise private and social benefits associated with the adoption of energy-efficient choices.

### **1. Introduction**

According to Eurostat (2018), in 2016 the EU residential sector represented 25.4% of final energy consumption or 17.4% of gross inland energy consumption in the EU, that is approximately 283 million tonnes of oil equivalent (Mtoe). Most of this final energy consumption was covered by natural gas (37.1%) and electricity (24.5%). Electricity covered 100% of the energy needs for lighting and space cooling but also 94% of the other end-uses and 49.2% for cooking. More specifically, 56.6% of electricity was used for lighting and other electrical appliances, 26.3% for heating space and water, 11.0% for cooking, 1.1% for cooling and the rest for other end uses. It is, thus, commonly argued that enormous efficiency improvements could be achieved if old inefficient electrical appliances were replaced by more energy-efficient ones, offering a “win-win” opportunity to both save money and reduce negative externalities associated with energy production.

Governments around the world have adopted policies to increase energy efficiency. The apparent reality, however, is that energy-efficient technologies or appliances are not adopted, even when it makes sense for businesses and consumers to do so, based on their private costs and benefits. The “under-investment” in energy efficient technologies, is known as “energy efficiency gap” or “energy paradox” (Jaffe & Stavins, 1994), and has been high on research and policy agendas for at least three decades (e.g. Blumstein et al., 1980; Hirst and Brown, 1990; Jaffe and Stavins, 1994; Weber, 1997; Brown, 2001; Schleich, 2004; Rohdin et al., 2007; Sardianou, 2008; Chai and Yeo, 2012; Backlund et al., 2012; Gerarden et al., 2015). Previous research efforts suggest that energy-efficiency gap may be attributed to potential market and non-market failures, such as imperfect or asymmetric information, misplaced incentives, inattentiveness to future energy savings when purchasing energy-consuming products, biased beliefs regarding, for example, the energy consumption of the products and the future energy prices, bounded rationality and heuristic decision-making, etc. (e.g. Gerarden et al., 2015).

This paper wishes to add to the rich literature of studies exploring the reasons behind the energy efficiency gap. To this direction, it presents the results of a survey conducted

on a representative sample of approximately 500 Greek households via computer-assisted web interviewing (CAWI) in the context of the “Consumer Energy Efficiency Decision making (CONSEED)” project. The survey was designed and conducted so as to reach every type of household and gather information on the factors influencing households’ energy efficiency choices. More specifically, the survey was focused on refrigerators provided that they are reported to be one of the first assets, after a television, which are acquired by typical low-income households as their wealth increases (Wolfram et al., 2012). For instance, Anon (2014) estimated that in China the acquisition of refrigerators increased from 24%, in 1994, to 88% in 2014. According to Coulomb (2008), as cited by James et al. (2017), there were in use 1 billion refrigerators, fridge freezers and freezers. Four years later, in 2012, Barther & Götz (2012) estimated that households all round the world were using 1.4 billion units, an increase of 40%. An early study by Bertoldi and Atanasiu (2007), cited by Mills and Schleich (2010), estimated that refrigerators alone are responsible for 15% of residential electricity end-use. Furthermore, European Commission (2018) estimates that by switching to more energy efficient refrigerating appliances would allow Europe to save up to 4 TWh of electricity per year by 2020, and would prevent around 1.5 million tonnes annual emissions of CO<sub>2</sub>. Similar figures are reported by Barther & Götz (2012), using an average annual electricity consumption of 450 kWh per unit, who claim that despite the expected increase in the number of domestic cold appliances the worldwide annual electricity consumption could be reduced from 649 TWh to 475 TWh by 2020 and to 413 TWh by 2030.

The rest of the paper is structured, as follows. Section 2 provides information about the methodology and the background of the study. Section 3 presents the results of the survey. Finally, Section 4 concludes with the main findings of the research.

## **2. Methodology and background**

### **2.1. Literature review**

A number of studies have been conducted towards analysing the factors influencing the purchase energy-efficient household appliances (e.g. Hausman, 1979; Dubin and McFadden, 1984; Hirst and Brown, 1990; Howarth and Andersson, 1993; Kooreman and Steerneman, 1998; Thompson, 2002; Poortinga et al., 2003; Zarnikau, 2003; Turrentine and Kurani, 2007; Larrick and Sol, 2008; Davis, 2010; Allcott, 2011; Ward et al., 2011; Gillingham et al., 2012; Shen, 2012; Newell & Siikamäki, 2013). Some of these studies indicate the socio-demographic characteristics, e.g. gender, education level, income, and age, may relate to consumers’ purchasing decisions (e.g. Poortinga et al., 2003; Shen, 2012), where as other studies argue that characteristics, such as the gender, have no significant effects (e.g. Zarnikau, 2003). Moreover, attitudinal characteristics, e.g. respondents who state that they are concerned about the environment and tend to behave pro-environmentally, have been found to be positively related to purchases of energy-efficient appliances is scarce (e.g. Shen, 2012). Fewer studies have been carried out examine the impact of energy labels on consumer choices’ regarding household appliances, despite the fact that energy labelling is getting more and more common in marketplaces around the world. For instance, Banerjee and Solomon (2003) presented a meta-evaluation of five US energy labelling programs: Green Seal, Scientific Certification Systems, Energy Guide, Energy Star, and Green-e. They found that government programs, Energy Star in particular, were much more successful than the private programs. Especially for appliance energy labelling, the

private programs were found to have an almost insignificant effect on the market. Sammer and Wüstenhagen (2006) found that consumers in Switzerland placed a 30% premium on washing machines with an A versus a C rating on the European Energy Label using a stated preference experiment with consumers at major retail stores.

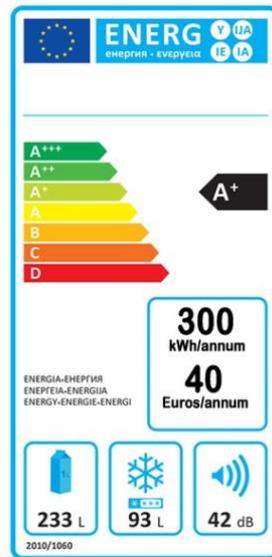
Focusing on refrigerators, McNeill and Wilkie (1979) examined whether disclosure of energy consumption, expressed in kWh per year, dollars per year, or dollars per month, had an impact on consumers' choice of refrigerator freezers. The disclosure format, physical vs. monetary units as well as annual vs. monthly information, did not seem to have an effect on consumers' appliance choices. Overall, the findings of the survey indicated that information disclosure would reduce energy consumption of refrigerator freezers by 2.3%. Hutton and Wilkie (1980) explored whether the disclosure of life-cycle costs or of energy costs in dollars per year had a stronger effect on women's purchasing decision for more energy efficient refrigerators. According to the results, displaying life-cycle rather than annual energy costs reduced energy costs significantly. Anderson and Claxton (1982) run an experiment for six weeks to study the effect of energy labels and staff training on consumers' purchase decisions for refrigerators. They concluded that there wasn't any effect on consumers' purchasing decisions concerning large refrigerators. Yet, for small refrigerators, disclosure of information on energy use seemed to induce consumers to purchase more energy efficient products. Meier and Whittier (1983) investigated consumer purchasing patterns for a standard and an energy-efficient refrigerator, which differed only in their initial cost and electricity consumption. They concluded that consumers tended to buy the more efficient model in regions with higher electricity prices. Verplanken and Weenig (1993) tested the effectiveness of energy labels on consumers' information search and decision strategies using a symbolic energy label, and a label in standard format. The results suggest that energy information is considered less under time pressure and that symbolic labels are optimal in relatively simple decision environments. Greening et al. (1997) examined multiple characteristics in a hedonic study of refrigerator prices (e.g. food compartment volume, freezer compartment volume, annual energy usage, etc.). They concluded that energy efficiency did not demonstrate a strong price effect. Moxnes (2004) used conjoint analysis to estimate utility functions for individuals that have recently bought a refrigerator. The study found that, in general, efficiency standards would increase utility, contrary to previous claims. Shen and Saijo (2009) examined consumers' WTP a one level upgrade in energy efficiency rank on the China Energy Efficiency Label by means of a hypothetical choice experiment. They found that WTP for the one step upgrade in refrigerators was \$76–\$89. More recently, Ward et al. (2011) examined how the ENERGY STAR label affects consumer preferences for refrigerators. Their results show that consumers are, on average, willing to pay an extra \$249.82–\$349.30 for a refrigerator that has been awarded the ENERGY STAR label. Furthermore, the survey provides evidence that respondents' WTP was motivated by both private (energy cost savings) and public (environmental) benefits. Kallbekken et al. (2013) analysed actual purchase decisions of fridge-freezers (and tumble driers) and tested the effects of disclosure of energy efficiency information on the average energy consumption of appliances sold. The differences in lifetime energy costs between the most and least efficient fridge-freezers were 250€ for an average life-time of the appliance of ten years. The results showed that the economic incentives for purchasing a more efficient cold appliance were rather weak probably because the difference in lifetime energy costs seemed to be rather small. Finally, Jeong & Kim (2015) investigated the effects of energy efficiency and environmental labels on households' choice of appliances (namely air conditioners and refrigerators). They found that

households showed a positive preference for labelled appliances, and an intention to pay more to purchase appliances with energy efficiency, and/or other environmental labels. Further, they concluded that more value was placed on energy efficiency labels than other environmental labels and on appliances used more frequently (i.e. refrigerators) than appliances used seasonally (i.e. air conditions). Readers interested in the effects of different energy label formats on consumers' choices may also refer to Rohling & Schubert (2013), who provide an extensive literature review.

## **2.2. Survey design and data collection and analysis**

The questionnaire involved seven different parts of questions assessing the participation, knowledge, attitude, practice, and demographics of the respondents related to the purchase of refrigerators. The first part included two introductory questions that examined the involvement of the respondent in the refrigerator purchase decision process and her/his knowledge about the annual energy costs of the owned refrigerator. The second part aimed at examining the importance of energy efficiency within a set of eleven different attributes related to the purchase of a refrigerator, namely: price, food compartment volume, freezer compartment volume, annual energy consumption, energy class, design, brand, years of warranty, after sales service and operating costs. In the third part, the respondent was faced with a discounting question eliciting the expected return on an energy efficiency investment when asking for the amount of expected electricity savings (which is beyond the scope of this paper). More specifically, the respondent was asked to state how much would she/he have to save in her/his electricity bill approximately per year during the next 10 years in order to pay an additional amount of money (i.e. 50, 100, 150€) for purchasing a more energy efficient refrigerator. The fourth part included a series of questions regarding the attitudes and beliefs of the respondent towards energy efficiency. To this end, a number of statements were presented (e.g. buying a more energy efficient refrigerator would reduce my household's environmental impact, all new refrigerators have similar energy efficiency levels, more energy efficient refrigerators are less reliable, I have a good understanding of my refrigerator's energy consumption, I am aware of electricity prices, I understand how much money I would save if I bought a more energy efficient refrigerator, I cannot afford buying a more energy efficient refrigerator, etc.). The fifth part examined the effects (understanding and utilisation) of the existing refrigerator energy label and the proposed monetary label. As regards the existing label, first the respondent was asked to state if she/he was aware of the existing energy label, if the label had influenced the selection of the owned refrigerator and, finally, what was the class of the owned refrigerator. Then, the respondent was asked to state how much she/he agreed or disagreed with a number of statements (e.g. it is understandable, it is trustworthy, it is manipulated by sellers, it would affect which refrigerator I choose, it helps me to understand how much energy a refrigerator uses, it helps me calculate how much a refrigerator will cost to run, etc.). Following, respondents were told that the existing energy label is about to change with a new one that would contain monetary information (i.e. the total energy cost per year, calculated by the energy consumption and an average electricity price) and were presented with the proposed monetary energy label (**Error! Reference source not found.**). Then they were asked to compare the monetary with the existing label using a number of statements (e.g. it is more understandable, it is more trustworthy, it is manipulated by sellers as well, it would affect more which refrigerator I choose, it helps me more to understand how much

energy a refrigerator uses, it helps me more calculate how much a refrigerator will cost to run, etc.) using an agreement/disagreement scale.



*Figure 1. The proposed monetary energy label presented to the respondents*

The sixth part included four questions that investigated the environmental behaviour of the respondent, i.e. how concerned she/he is about the environment, if she/he believes that we need to act now on climate change, if she/he believes that households' choices can affect climate change, and, finally, if she/he would be willing to buy a more energy efficient refrigerator, even if it's more expensive, so as to contribute to the minimization of future impacts of climate change. The seventh and last section of the questionnaire collected typical demographic and socioeconomic data.

Information was collected via CAWI (computer-assisted web interviewing) by an experienced market research and opinion polling company, which is a member of the Association of Greek Market & Opinion Research Companies (AGMORC), the World Association for Public Opinion Research (WAPOR) and follows quality assurance procedures that have been certified by AGMORC's Data Collection Quality Control. In total, 496 questionnaires were successfully completed.

Descriptive statistics and econometric models were employed to:

- Identify the factors that are most relevant in determining consumption decisions for refrigerators across different consumer groups and locations (e.g. urban and rural areas)
- Advance the current knowledge on how different consumer groups (with special attention to gender, age, income, education, and other important socio-economic characteristics) make energy efficiency investment decisions
- Estimate the impact of the EU labelling schemes on energy efficient investments and barriers and test whether displaying monetary usage labels would further encourage households to purchase more efficient home appliances.

The descriptive statistics was used to quantitatively explore, summarize and describe the data collected from the respondents with respect to energy efficient decisions and to explain their socio-demographic background. Moreover, statistical tests, such as the

chi-square test and the Kruskal-Wallis and Mann-Whitney non-parametric tests, were carried out to capture the role of gender and other demographic characteristics. The parametric models aimed at exploring the association between categorical variables and respondents' characteristics. More specifically, two models were used in particular: (a) a binary logistic regression model for dichotomous data and (b) an ordered logistic regression model for discrete data which are ordinal in nature. The theoretical framework of the binary and ordered logistic models, including the model specification and method of evaluation, are discussed in detail in the relevant literature (e.g. Aldrich & Nelson, 1984; Anderson, 1984; Brant, 1990; Williams, 2006; Greene, 2012; Long & Freese, 2014) Therefore, in this paper only the general specifications of each model are given below.

$$\Pr(y_j = 1 | \mathbf{x}_j) = \Pr(\mathbf{x}_j \boldsymbol{\beta} + u > 0) = \frac{\exp(\mathbf{x}_j \boldsymbol{\beta})}{1 + \exp(\mathbf{x}_j \boldsymbol{\beta})}$$

where  $\mathbf{x}_j$  is a vector of covariates,  $\boldsymbol{\beta}$  is a vector of regression coefficients and  $u$  is logistically distributed.

The ordered logistic regression model is a direct generalization of the ordinary binary logistic regression model. In ordered logistic regression, the probability of observing outcome  $i$  corresponds to the probability that the estimated linear function, plus random error  $u_j$  which is independently and identically distributed with the logistic distribution, is within the range of the cutpoints estimated for the outcome:

$$\begin{aligned} \Pr(y_j = i | \mathbf{x}_j) &= \Pr(\kappa_{i-1} < \mathbf{x}_j \boldsymbol{\beta} + u \leq \kappa_i) \\ &= \frac{1}{1 + \exp(-\kappa_i + \mathbf{x}_j \boldsymbol{\beta})} - \frac{1}{1 + \exp(-\kappa_{i-1} + \mathbf{x}_j \boldsymbol{\beta})} \end{aligned}$$

The coefficients  $\boldsymbol{\beta}$  are estimated together with the cutpoints  $\kappa_1, \kappa_2, \dots, \kappa_{k-1}$ , where  $\kappa$  is the number of possible outcomes and  $\kappa_0$  is defined as  $-\infty$  and  $\kappa_k$  as  $+\infty$ .

### 3. Results

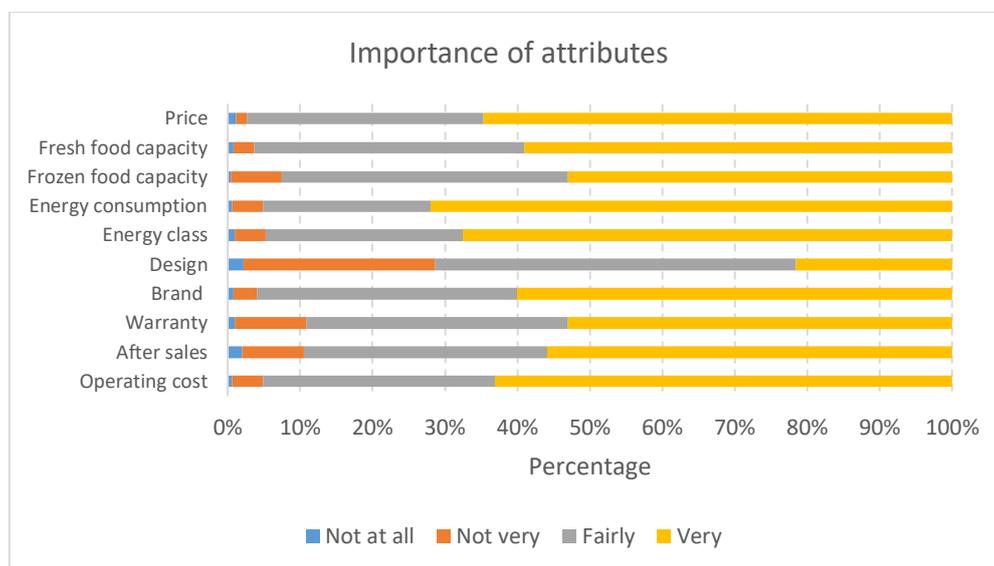
#### 3.1. Respondents' characteristics

The sample is representative of the Greek population with respect to key characteristics, i.e. gender, income, age, household size, education and income. More specifically, as regards the demographic characteristics of the respondents, 49.8% were women and 50.2% were men. In total, 22.3% of the respondents were less than 30 years old, 27.6% were between 30 and 40 years old, 22.6% were between 40 and 50 years old, 21.9% were between 50 and 60 years old and the rest were more than 60 years old. Further, 57.3% said that they live with their spouse/partner (with or without children), 20% live with their parents or other relatives, 11.9% live alone and 8.4% share a property with non-family members. Moreover, 2.5% preferred not to answer this question. Regarding the marital status, 33.8% are single (never married), 52.9% are married, or in a domestic partnership, 1.7% are widowed, 7.9% are divorced or separated and the rest preferred not to answer. About 80% of the households have less than 4 members (more than half

less than 3 members). Furthermore, 36.6% of all households have own children under age 18 living in the household. About 1% have not reached high-school, 21.5% have stopped their education at the end of senior high-school, 17.7% have finished a 2-year degree, 44% have a three-, four- or five-year degree and about 15% have an MSc or a PhD degree. About 62% of the respondents are employed (16.5% are self-employed) and 15.4% are unemployed. The rest of them declare pensioners (9.1%), students (8.3%) and housekeepers (4.7%). More than half (i.e. 51.2%) of the respondents have a monthly household income less than €1,100 (25.5% less than €750), 31% between €1,100 and €1,800, 7.9% between €1,800 and €2,200 and less than 10% more than €2,200. Based on the ESOMAR social grades, 20.6% of the households belong to the A/B (Upper) class, 32.3% to the C1 (Middle to upper) class, 32.7% to the C2 (Middle to lower) class and 14.5% to the D/E (Lower) class. In connection with above-described statistics, 14.6% of the respondents say that they find it very difficult to live on current income, 33.3% find it difficult to live on current income, 32.1% cope on current income and the rest (about 17.5%) declare that they live comfortably or very comfortably on current income.

### 3.2. Attitudes and beliefs

As shown in Figure 2, 72% of the respondents declare that energy consumption is a very important attribute when selecting a new refrigerator, followed by energy class (68%), price (64%) and operating costs (62%). At the other end lie the design (only 23% say that it is a very important attribute and 34% believe that it's not at all or fairly important), followed by warranty (53% say that it is very important and 12% that it's not at all or fairly important) and after sales service (56% say that it is very important and 12% that it's not at all or fairly important).

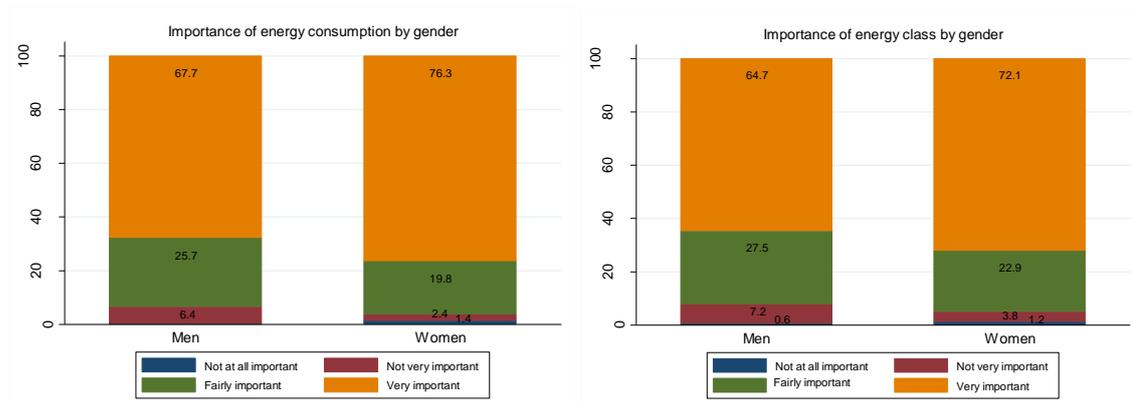


**Figure 2.** Importance of selected attributes for purchasing refrigerators

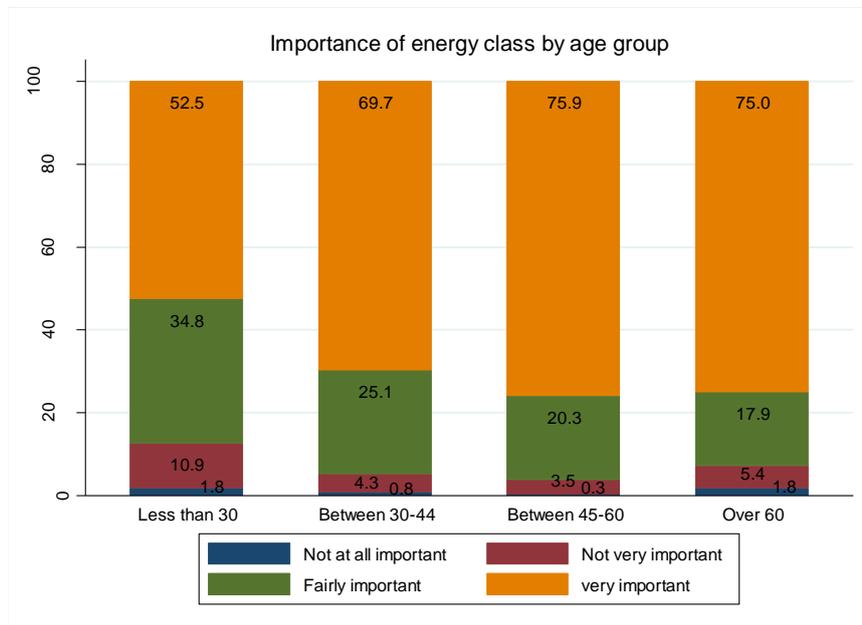
Chi-square tests were conducted to assess associations between demographic variables (gender in particular) and the importance of the attributes of the purchasing decision. The results show that women pay more attention than men to the energy consumption

( $\chi^2(3) = 19.7983, p = 0.000$ ), the energy class ( $\chi^2(3) = 10.2476, p = 0.017$ ), the fresh food capacity ( $\chi^2(3) = 26.4267, p = 0.000$ ), and the frozen food capacity ( $\chi^2(3) = 15.2581, p = 0.002$ ). Fig. 3 shows the relative frequencies between men and women for the importance of the energy consumption and the energy class, respectively. There were no statistically significant associations between the rest of the attributes and the gender of the respondents.

Furthermore, the age of the respondent affects the importance of the energy consumption ( $\chi^2(9) = 52.1581, p = 0.000$ ), the energy class ( $\chi^2(9) = 43.0247, p = 0.000$ ), and the operating cost ( $\chi^2(9) = 30.1958, p = 0.000$ ). In general, it seems that younger people pay less attention to the energy consumption and class of the refrigerator than the older ones (Fig. 4).



**Figure 3.** Importance of energy consumption and energy class for men and women

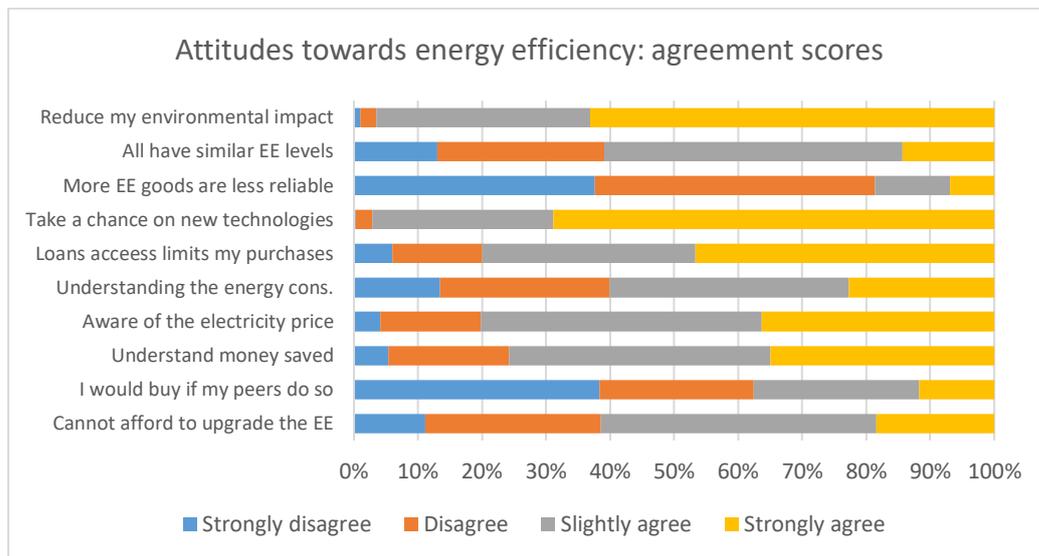


**Figure 4.** Importance of energy class for different age classes

More than 95% of the respondents strongly or slightly agree that buying a more energy efficient refrigerator would reduce the impact of their household on the environment and are willing to take a chance on new technologies so to reduce their energy

consumption. Further, almost 40% don't believe that all new refrigerators have similar energy efficiency levels and 80% do not accept that more energy efficient refrigerators are less reliable. Nevertheless, 63% of them declare that they cannot afford to buy an energy efficient refrigerator and, in addition, more than 80% say that the lack of financial incentives is an important barrier towards making more energy efficient choices.

The information level of the respondents regarding the energy consumption of their refrigerator, the money savings from buying a more energy efficient refrigerator and the electricity prices is above average, according to the answers provided. More specifically, about 65% of the respondents strongly or slightly agree that have a have a good understanding of the refrigerator's energy consumption, 85% strongly or slightly agree that understand how much money they would save if they bought a more energy efficient refrigerator and 80% strongly or slightly agree that are aware of electricity prices. Nevertheless, more than 60% of them declared that they don't know the amount of money paid to the electricity utility each year for the operation of their refrigerator, and, additionally, only 10% provided a rational answer to this question.

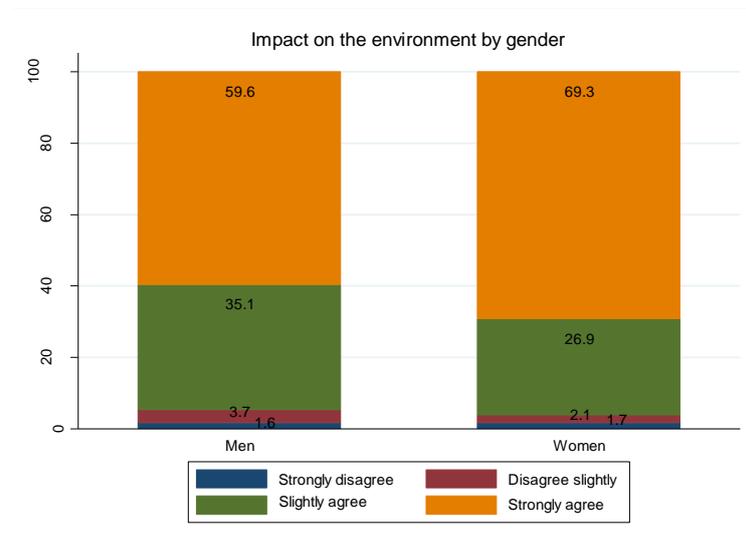


**Figure 5.** Agreement with behavioural statements on energy efficiency

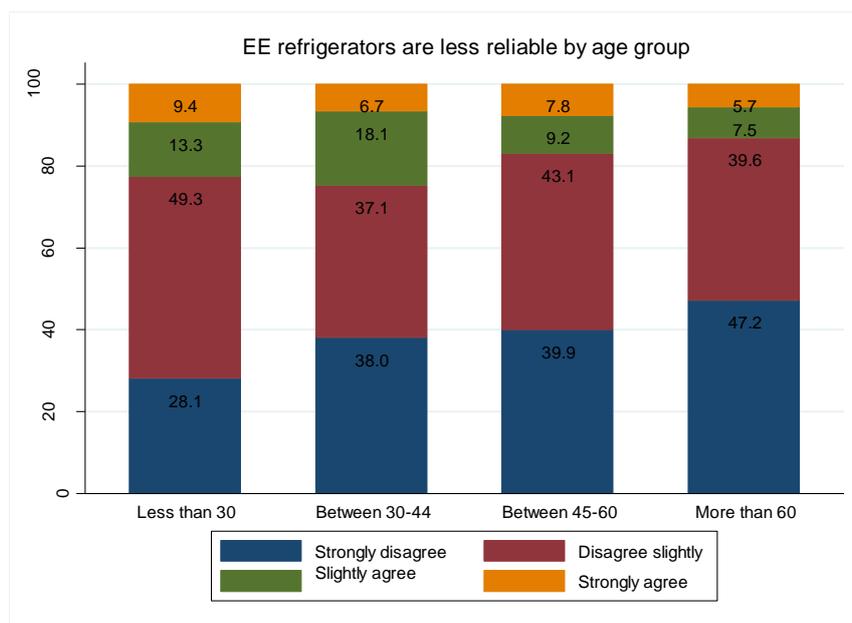
Again, chi-square tests were carried out to capture the role of gender and other demographic characteristics. Regarding the gender, the statistical tests show that generally women agree more than men that the purchase of a more energy efficient refrigerator would reduce the impact of their household on the environment ( $\chi^2(3) = 10.8036, p = 0.013$ ), as shown in Fig. 6, and that they don't have a good understanding of their refrigerator's energy consumption ( $\chi^2(3) = 8.2294, p = 0.042$ ). No other statistically significant associations were observed between gender and the other parameters.

The age of the respondent also plays a significant role in the agreement with the above-mentioned energy efficiency statements. To wit, younger people are less capable of buying an energy efficient refrigerator ( $\chi^2(9) = 21.1753, p = 0.012$ ), more impacted by the lack of financial incentives ( $\chi^2(9) = 26.9512, p = 0.001$ ), more convinced that

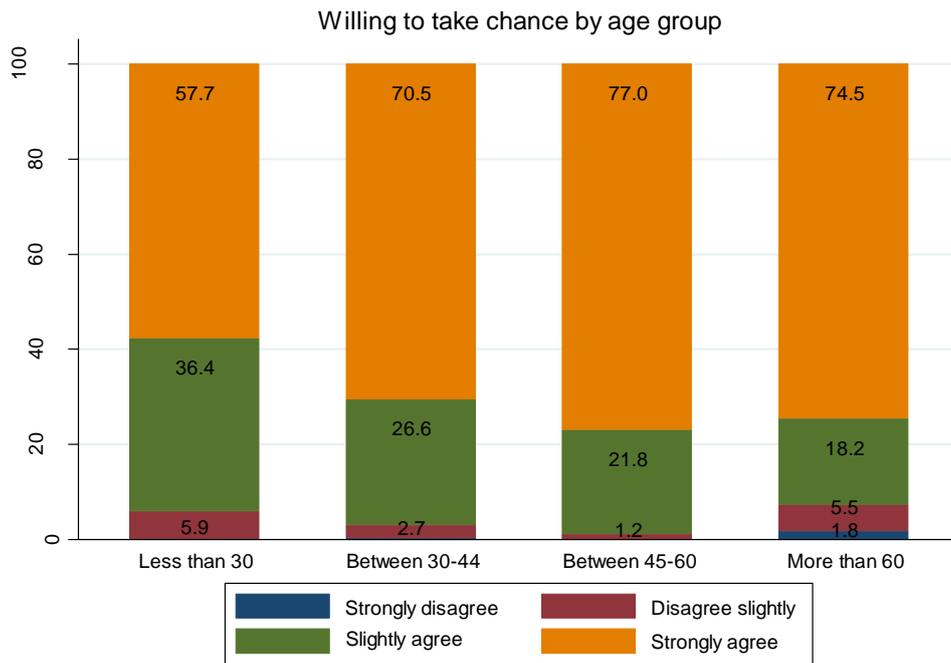
more energy efficient refrigerators are less reliable ( $\chi^2(9) = 23.9195$ ,  $p = 0.004$ ), as shown in Fig. 7, and, interestingly, are less willing to take a chance on new technologies to reduce their energy consumption ( $\chi^2(9) = 38.7163$ ,  $p = 0.000$ ) (Fig. 8).



**Figure 6.** Reduction of household's environmental impact for men and women

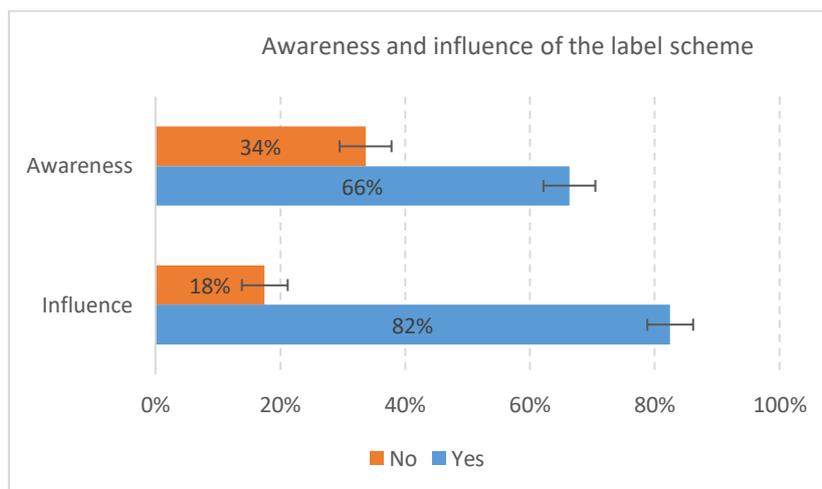


**Figure 7.** Reliability of energy efficient refrigerators by age group



**Figure 8.** Willingness to take a chance on new technologies by age group

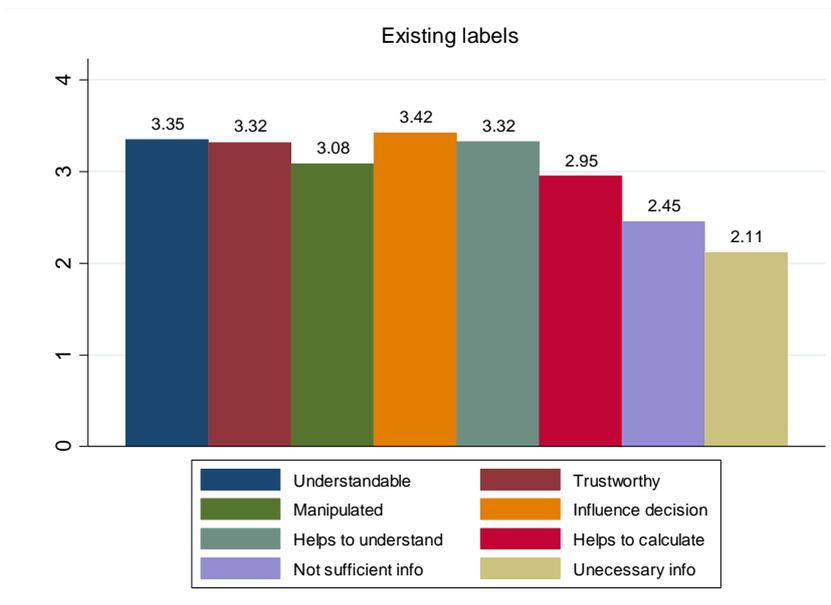
As shown in Fig. 9, two-thirds of the respondents state that they are aware of the existing energy labels. More importantly, 82% of them claim that the energy label did affect the purchase of their refrigerator. According to the econometric models, which are presented in the next section, both parameters, i.e. the awareness of the energy label and its role in selecting a more energy efficient refrigerator, are dependent on a number of attitudinal and demographic factors including, for example, gender, age, beliefs about the reliability of energy efficient refrigerators, awareness of electricity prices, etc.



**Figure 9.** Awareness of energy label and its influence on purchase

According to the responses, less than 20% of the existing refrigerators are of the A+++ class. The majority (i.e. 43%) are of A++ class, 27% are of A+ class, and the rest 12% are of A class or lower.

As regards the refrigerator energy labels (Fig. 10), Greek households believe that the existing refrigerator energy labels have an influence on the purchase decision (3.4/4), are understandable (3.4/4) and trustworthy (3.3/4), and help to understand the refrigerator’s energy consumption (3.3/4). Further, they claim that the existing labels are manipulated by the sellers (3.1/4), are helpful for calculating the energy costs, and could include more sufficient information (2.5/4). Finally, it seems that they are divided around the issue of the unnecessary information (2.1/4). The role of gender, age and other demographic factors was examined by means of the Kruskal-Wallis and the Mann-Whitney non-parametric tests. Nevertheless, the null hypothesis of equal populations could not be rejected.

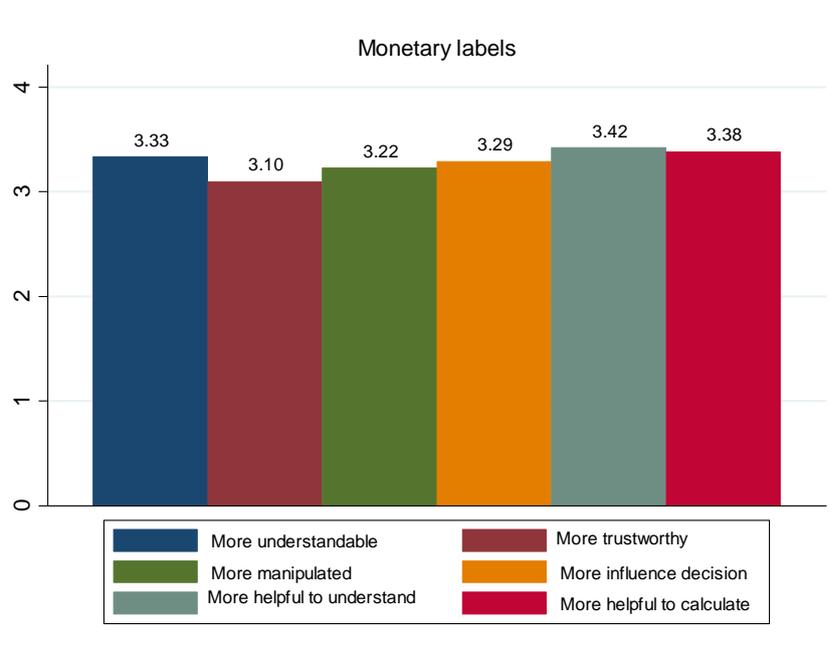


**Figure 10.** Beliefs about the existing refrigerator energy labels

Turning to the monetary labels (Fig. 11), respondents believe that they are more helpful for calculating how much it would cost to operate a refrigerator (3.4/4) and for understanding how much energy is consumed by a refrigerator (3.4/4). The latter finding is a little bit unexpected given that existing labels provide the same piece of information as far as the electricity consumption is concerned. Furthermore, they believe that the proposed labels are more understandable (3.3/4) and would influence more their decision (3.3/4). Finally, respondents support that the proposed labels would be also manipulated by the sellers (3.2/4), although they find them more trustworthy (3.1/4).

According to the Mann-Whitney test, women believe more than men that the proposed label is more helpful towards calculating the energy costs of the refrigerator ( $p = 0.022$ ) and that it would influence more than the existing label the purchase decision ( $p = 0.074$ ). Moreover, older people are more convinced about the proposed label.

Nevertheless, the null hypothesis of equal populations is rejected according to the results of the Kruskal-Wallis test for the following attributes of the proposed label: it's understandable ( $\chi^2 = 8.066$ , d.f. = 3,  $p = 0.0447$ ), it's trustworthy ( $\chi^2 = 7.496$ , d.f. = 3,  $p = 0.0577$ ), and it helps to calculate the cost of energy ( $\chi^2 = 8.013$ , d.f. = 3,  $p = 0.0458$ ).



*Figure 11. Comparison of monetary vs. existing energy labels (Greece)*

### 3.3. Multivariate regression analysis

The quantitative data from the Greek consumer survey were also analysed using multivariate regression models (i.e. binary and ordered logistic) to estimate the relative importance of the attitudinal and demographic factors influencing consumer decision making and how the decision making varies across different consumer groups in terms of age, gender, etc. More specifically, different models were formed to analyse the factors influencing the importance of the energy efficiency attribute, the awareness and the influence of the existing energy labels, and the willingness to buy a more energy efficient refrigerator.

#### A. Importance of energy consumption in choosing refrigerators

An ordered logistic model was used to estimate the factors influencing the importance of energy consumption (dependent variable coded as: 1 = Not at all important/Not very important; 2 = Fairly important; 3 = Very important). The results are reported in Table 1.

According to the model, the energy efficiency is more important for those who believe that they have to act now for combating climate change ( $p < 0.01$ ), they are aware of the energy labels ( $p < 0.01$ ), they have more children ( $p < 0.01$ ), they are older ( $p < 0.1$ ), they are women ( $p < 0.05$ ) and they have less monthly income ( $p < 0.1$ ). Using the odds ratios, it is estimated that the odds of declaring that the energy efficiency is very important

versus fairly important for those who wish to act now for climate change are 1.86 times greater, given that all of the other variables in the model are held constant. Because of the proportional odds assumption the same increase, 1.86 times, is found between the odds of being “fairly important” versus the combined “not at all important/not very important”. Likewise, the odds of believing that the energy efficiency is very important versus fairly important are 2 times higher for those who are aware of the energy labels. Moreover, the odds are almost 1.5 times higher for women and for those who have children and 1.1 times higher for older people. Finally, the odds are reduced to 0.9 for those having higher income.

**Table 1.** Determinants of the importance of energy efficiency (Greece)

VARIABLES	
Act now for climate change	0.621*** (0.198)
Aware of energy labels	0.697*** (0.225)
Gender	0.394** (0.224)
Age class	0.0706* (0.0449)
Number of children	0.445*** (0.148)
Monthly income	-0.102* (0.0643)
Constant cut1	0.367 (0.836)
Constant cut2	2.627*** (0.832)
Observations	441
Pseudo R <sup>2</sup>	0.0620
Log likelihood	-293.4

Standard errors in parentheses

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

### **B. Awareness of the existing refrigerator energy label**

A binary logistic model was implemented, the results of which are given in Table 2, to explore the factors influencing the awareness of the existing energy labels (dependent variable coded as: 1 = Yes; 0 = No).

Those who believe that new refrigerators do not have similar energy efficiency gains (p<0.01), they have a good understanding of their refrigerator’s energy consumption (p<0.01), they were influenced by the energy label when they bought their refrigerator (p<0.01), they are aware of the electricity prices (p<0.05), they are women (not statistically significant at p=0.1), older (p<0.1), and live in urban areas (p<0.1), are more likely to be aware of the existing refrigerator energy label. More specifically, the odds of being aware of the energy label are 6.4 times greater for those who were affected by the energy label when they bought their current refrigerator, given that all of the other variables in the model are held constant. Moreover, the odds of being aware

are 2 times greater for those who have a good understanding of the refrigerator's energy consumption and 1.4 times greater for those who are aware of the electricity prices. Moreover, the odds are almost 1.5 times higher for women and 1.1 times higher for older people. Finally, the odds are reduced to 0.1 for those living in non-urban areas and to 0.6 for those who believe that all new refrigerators offer similar energy efficiency gains.

**Table 2.** Determinants of energy label awareness

VARIABLES	
All new refr. similar EE	-0.480*** (0.176)
Good understanding of refr. consumption	0.651*** (0.161)
Aware of electricity prices	0.289 (0.178)
Influence of EE on purchase	1.856*** (0.316)
Gender	0.380 (0.281)
Age class	0.098* (0.060)
Urban	-2.024*** (0.657)
Constant	-0.453 (1.128)
Observations	393
Pseudo R <sup>2</sup>	0.23
Log likelihood	-167.4

Standard errors in parentheses

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

### C. Influence of the existing energy label in choosing refrigerators

In order to investigate the determinants of the energy label's influence on consumers judgment (dependent variable coded as: 1 = Yes; 0 = No), a binary logistic model was used the results of which are given in Table 3 **Error! Reference source not found..**

Based on the coefficients of the model, those who believe that more energy efficient refrigerators reduce households' impact on the environment ( $p<0.01$ ), they have a good understanding of their refrigerator's energy consumption ( $p<0.01$ ), they are aware of the refrigerator energy label ( $p<0.01$ ), they believe that we have to combat now climate change ( $p<0.01$ ), they are men ( $p=0.05$ ) and belong to a higher social class ( $p<0.05$ ), are more likely to be influences by the energy label when choosing a refrigerator. The odds of being affected by the energy label are 7 times greater for those who are aware of the energy label, and almost 2 times greater for those who believe that (i) we have to act now for tackling with climate change impacts, (ii) more energy efficient refrigerators reduce households' impact on the environment, and (iii) have a good understanding of their refrigerator's energy consumption. The odds are reduced to 0.5 for women and to 0.7 for those who belong to a lower social class.

**Table 3.** Determinants of the energy label's influence

VARIABLES	
More EE regr. reduce HH impacts	0.684*** (0.247)
Good understanding of refr. consumption	0.522*** (0.173)
Label awareness	1.958*** (0.320)
Act now for climate change	0.692*** (0.268)
Gender	-0.645** (0.322)
Social class	-0.344** (0.161)
Constant	-4.144*** (1.351)
Observations	393
Pseudo R <sup>2</sup>	0.25
Log likelihood	-138.2

Standard errors in parentheses

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

#### D. Willingness to buy an energy efficient refrigerator

As regards the factors influencing the willingness of the respondent to buy a more energy efficient refrigerator (dependent variable coded as: 1 = Yes; 0 = No) in order to minimise their impact on climate change, a binary logistic model was run, the results of which are presented in Table 4.

The model illustrates that the willingness to buy a more energy efficient refrigerator is positively affected by the belief that energy efficient refrigerators reduce the impacts of the household on the environment ( $p<0.1$ ), the good understanding of the energy consumption of the refrigerator ( $p<0.01$ ), the awareness of the energy label ( $p<0.05$ ), the concern about the environment ( $p<0.05$ ), the willingness to act now for combating climate change ( $p<0.01$ ), the income of the respondent, i.e. wealthier people are keen to buy an energy efficient refrigerator ( $p<0.05$ ), and the age of the respondent, i.e. younger people are more willing to buy an energy efficient refrigerator ( $p<0.01$ ). Furthermore, those who pay more attention on the price of the refrigerator are less willing to buy an energy efficient refrigerator ( $p<0.05$ ). The odds of being willing to buy an energy efficient refrigerator are almost 3 times greater for those who believe that we should act now in order to combat climate change, 1.8 times greater for those who are aware of the energy labels, and 1.5 times greater for those who are concerned about the environment, believe that energy efficient refrigerators reduce households' impacts on the environment, and have a good understanding of the energy consumption of their refrigerator. When the age of the respondent and the importance of the price increase, the odds of buying a more energy efficient refrigerator reduce by 0.8 and 0.6, respectively.

**Table 4.** Determinants of the willingness to buy an EE refrigerator (Greece)

VARIABLES	(1) quest14_new
Importance of price	-0.515** (0.235)
More EE refr. reduce HH impacts	0.401* (0.209)
Good understanding of refr. consumption	0.393*** (0.142)
Label awareness	0.559** (0.274)
Concerned about the environment	0.382** (0.166)
Act now for climate change	1.062*** (0.256)
Monthly income	0.178** (0.0776)
Age class	-0.176*** (0.0539)
Constant	-4.622*** (1.347)
Observations	419
Pseudo R <sup>2</sup>	0.173
Log likelihood	-196.8

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

#### 4. Discussion and conclusions

To the authors' best knowledge, this is the first study attempting to gather information on the factors influencing Greek households' energy efficiency choices and, through this, to explore the reasons behind the energy efficiency gap in Greek residential sector.

According to the responses given, refrigerator's energy efficiency (as expressed through the energy consumption and the energy class attributes) appears to be the dominant factor related to the purchase of a refrigerator. In consistency with similar surveys (e.g. Poortinga et al., 2003; Shen, 2012), the gender of the respondent has a significant effect, together with age and income. Further, the importance of energy efficiency is positively affected by the awareness of energy label and by the pro-environmental orientation and behaviour of the respondent, a finding also noticed by Shen (2012). The consumers' purchase decision making process seems also to be affected by the energy label of the refrigerator (to wit, the odds of being affected by the energy label are 7 times greater for those who are aware of the energy label). More specifically, the influence of the energy label is stronger for men and those belonging to a higher social class. The same stands for those who take a pro-environmental stance (i.e. they believe that more energy efficient refrigerators reduce households' impact on the environment and that we have to combat now climate change) and have a good understanding of their refrigerator's energy consumption. Finally, the energy efficiency investment decision was examined through respondent's willingness to buy a more energy efficient refrigerator, even if it's more expensive, to contribute to the minimization of future impacts of climate change. The results of the study support that

the good understanding of the energy consumption of the refrigerator and the awareness of the energy label are positively correlated with the willingness towards acquisition of more energy efficient refrigerators. Similarly, wealthier and younger people and those who are concerned about the environment and the impacts of climate change are keen to buy energy efficient refrigerators (e.g. the odds of being willing to buy an energy efficient refrigerator are almost 3 times greater for those who believe that we should act now in order to combat climate change). On the other hand, the price of the refrigerator seems to be a barrier, since the odds of buying a more energy efficient refrigerator reduce by 0.6 for those who pay more attention on this factor.

As regards the monetary labels, respondents state that they are more helpful for calculating the energy cost of the refrigerator. Moreover, they believe that the proposed labels are more understandable and would probably influence more their decision. Indeed, women believe more than men that the proposed label is more helpful towards calculating the energy costs of the refrigerator and that it would influence more than the existing label the purchase decision. Given the importance of the energy label in consumers' purchase decision making process, this conclusion should be thoroughly considered by policy makers in EU and elsewhere.

Concluding, the findings of the survey are not an end-to-itself but a vehicle for behavioural research in energy efficient decisions. The data collected and analysed can be used to populate theoretical models regarding energy efficiency gap and determine the degree to which each factor contributes to the phenomenon. Moreover, they could help decision-makers in better understand the energy paradox, and, thus, could contribute to crafting better public policy responses that would maximise private and social benefits associated with the adoption of energy-efficient choices.

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