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EXPERIMENTAL EVIDENCE ON CONSUMER DECISION-MAKING TOWARDS ENERGY-EFFICIENT APPLIANCES

PhD TESIS

María del Mar Solà Osoro

Supervised by IBON GALARRAGA GALLASTEGUI & MARTA ESCAPA GARCÍA

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PROGRAMA DE DOCTORADO INTERUNIVERSITARIO EN ECONOMÍA: INSTRUMENTOS DEL ANÁLISIS ECONÓMICO

Universidad de Cantabria, Universidad de Oviedo y Universidad del País Vasco (UPV/EHU)

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List Of Acronyms

CECOBI – Confederación Empresarial de Comercio de Bizkaia

DW – Dishwasher

EC – Energy consumption

EE – Energy Efficiency

FMG – Federación Mercantil de Gipuzkoa

GHG – Greenhouse gas

LEC – Lifetime energy cost

LES – Lifetime energy savings

OCU – Organización de Consumidores y Usuarios

TD – Tumble driers

WM – Washing machines

WTP – Willingness to pay

Introduction

The group of scientists from all over the world who make up the Intergovernmental Panel on Climate Change (IPCC) have repeatedly confirmed that human action has warmed the atmosphere, ocean and land due to increased levels of greenhouse gas (GHG) emissions, which generate climate change. According to the last report, global surface temperature will continue to increase until at least mid-century under all emissions scenarios considered (IPCC, 2021). Unless CO2 and other GHG emissions are reduced dramatically, global warming of 1.5ºC and 2ºC will be exceeded within the 21st century (IPCC, 2021). This will generate more frequent extreme climate events such as droughts, heat waves and storms, and consequently huge economic costs. All this will, of course, also have severe public health and environmental implications. Many of these impacts are already being felt and a vast amount of evidence has been collected over the years.

The climate change problem clearly has global public good characteristics, so the International community has come together in the United Nations Framework Convention on Climate Change (UNFCCC) and holds annual United Nations Climate Change Conferences of the Parties (known as COPs). Almost thirty years after the 1992 Earth Summit in Rio and after the first COP in Bonn in 1995, GHG emissions continue to increase. More recently, COP21 was held in Paris and approved a new global agreement: the so-called Paris Agreement. This sought to hold the increase in global temperature to below 2ºC above preindustrial levels and to pursue efforts to limit that increase to 1.5ºC[1]. The agreement was signed by 195 countries and ratified by 190. It entered into force in 2016. Annual COPs have been taking place since, with the most recent being COP26, which was held in 2021 in Glasgow, where the many points agreed included some increased emission reduction efforts. Indeed, it is well known that energy production and consumption are among the main sources of GHG emissions globally. There are two main ways to reduce the emissions associated with energy use: the promotion of renewable energies and the reduction of energy demand. It is in the latter that energy efficiency (EE) plays a very significant role.

The EU seeks to achieve energy savings of at least 32.5% in all sectors by 2030 under its Energy Efficiency Directive (2018/2002). EE may be defined as the technical attribute by which a product performs the same task but consumes less energy in doing so (Linares and Labandeira, 2010).

EE can lead to several private and public benefits (such as cost reductions and decreases in carbon emissions respectively), but these are not always enough to boost investments in it. This underinvestment is known as the *energy efficiency gap*: it refers to situations in which beneficial investments are not made and/or apparently non-beneficial ones are made (Jaffe and Stavins, 1994a;

[1] For further information on the Paris agreement, see Roman de Lara and Galarraga (2016).

Schubert and Stadelmann, 2015). There are various explanations for this gap, which can be grouped as follows: (i) market failures (including informational failures); (ii) behavioural failures; and (iii) other factors. Understanding the causes of the energy efficiency gap is very important for the design of EE policies if the intention is to boost investment.

This dissertation deals with some of the policy instruments designed to overcome this gap at household level and ways to enhance their effectiveness. Note that household energy consumption accounts for 26% of total consumption in Europe and 17% of global GHGs (Eurostat, 2021; UN and GlobalABC, 2021). It is important to remark that this dissertation will focuse on the demand side and consumer decision-making, without considering the supply side.

Objectives and structure

Chapter 1 of this dissertation comprises a literature review to help provide a better understanding of the aforementioned reasons for the EE gap and the policy instruments designed to address it. This review helps understand the main barriers reported in the literature, with particular attention to household appliances. To address the failures that lie behind the energy efficiency gap there are several policy instruments such as: (i) command and control; (ii) price instruments; and (iii) informational instruments. This chapter reviews the empirical evidence on some EE policies and discusses their effectiveness.

(i) Command and control instruments include codes and standards and are commonly used to address market failures. They seem to be effective as policies but they have to overcome several barriers and are thus often hard to implement.

(ii) Price instruments include subsidies and taxes, and are generally used to deal with different market and behavioural failures. This review shows that subsidies and taxes are not generally effective, but rebate programmes (a special type of subsidies) present mixed results, sometimes proving effective and sometimes presenting significant shortcomings.

(iii) Informational instruments include energy labels, smart meters and information feedback tools and energy audits. They are designed to address behavioural and informational instruments. The effectiveness of informational policies is not always ensured: it depends on the country, sector and product category. Energy labels are one of the most widely used policies in the EU for increasing the EE level of household appliances. However, their effectiveness in promoting energy-efficient purchases has sometimes been called into question. Information feedback tools seem to be effective as they work as a constant reminder of energy-efficient behaviour.

As mentioned above, the effectiveness of EE labels has been called into question in recent years[2] (Carroll et al., 2016b; Waechter et al., 2015a, 2015b). One of the reasons for this is that consumers may find it hard fully to understand the energy consumption information provided on labels (in kWh/year). To avoid this problem, some authors propose converting energy consumption information into monetary information, but there are no clear conclusions concerning the effectiveness of such a measure (Carroll et al., 2016b; Kallbekken et al., 2013; Waechter et al., 2015a).

It is at this specific point that Chapter 1 connects with Chapters 2 and 3, which seek to test how providing monetary information on labels may affect consumer decision-making/energy-efficient purchases.

More specifically, **Chapter 2** analyses whether providing monetary information on ***lifetime energy savings*** for household appliances can significantly increase purchases of energy-efficient ones. To that end, a field experiment was carried out with *small retailers* in Spain in 2018. The experiment involved three types of appliance: washing machines, fridges and dishwashers. The impact of monetary information on actual purchases of appliances was tested in different ways: (i) by including a monetary label to display energy savings over the lifetime of the product; (ii) by having sales staff provide monetary information; and (iii) by a combination of (i) and (ii).

26 retailers took part in the experiment and the effectiveness of providing monetary information was found to depend on the type of appliance and on the specific way in which the information was provided. For washing machines, providing monetary information via a monetary label seemed to be effective in promoting the purchase of highly energy-efficient appliances. For fridges both monetary information provided by staff alone and the combination of a monetary label and information from sales staff seemed to be effective in encouraging purchases of A^{+++} fridges. Surprisingly, no effect was found for dishwashers.

By contrast with information on "savings", **Chapter 3** tests how providing monetary information on ***lifetime energy cost*** **may** affect the purchase of high-efficiency appliances. To that end, a field experiment was carried out with a Spanish *large retailer,* also in 2018, for washing machines, fridges, dishwashers and tumble driers. The impact on actual purchases of monetary information was tested

[2] EE labels are revised periodically . In fact, the latest EE label entered into force in March 2021: https://ec.europa.eu/info/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/energy-label-and-ecodesign/about_en#a-new-generation-of-labels

in two different ways: (i) monetary information provided by sales staff; and (ii) monetary information provided by the sales staff plus a label. 29 stores took part in the experiment. As in the previous chapter, our findings indicate that the effectiveness of providing monetary information depends on the appliance analysed and the specific way in which information is provided. On one hand, monetary information provided by sales staff alone was effective in promoting the purchase of A^{++} washing machines, fridges and dishwashers, but no effect was found for tumble driers. On the other hand, monetary information by sales staff plus a label was found to be effective in increasing sales of A^{++} washing machines and dishwashers as well as A^{+++} tumble driers. No effect was found for fridges.

Prior to the experiment, there was a widely publicised rebate scheme (the "RENOVE programme") in place in the regions where some of the stores analysed were located. Interestingly, we found that in those places where the RENOVE programme had been running, its effect may have lasted for some months after its end date. This is a very interesting finding in regard to what we have called the *Memory effect* of rebate programmes. To the best of our knowledge, this effect has not been reported before in the relevant academic literature. It suggests that the effect of the RENOVE (and other rebate programmes) may need to be explored and researched over a longer period, including the period just after the programme ends. That is exactly what is done in the next chapter of this dissertation.

The main research question in **Chapter 4** is to check in a controlled environment for evidence of the memory effect found in Chapter 3 and to determine what factors may promote this effect. We considered different risk framings that could lead to different cognitive processes, and therefore different appliance purchasing decisions.

The experiment was staged at the Bilbao Laboratory of Experimental Analysis (Bilbao-Labean[3]) at the University of the Basque Country in March 2022, using a computer-based form. 166 subjects took part, in 4 different sessions. This lab experiment included 3 different parts: (i) a risk-elicitation task to measure subject preferences; (ii) a role-playing exercise to check for evidence of the memory effect in the purchasing decision of a fridge; (iii) a post-experiment survey to control for differences in the choices of participants and explain their decisions as well as other personal factors (e.g. socio-demographic factors).

The design of the experiment staged enables the factors that nudge consumers towards investing in EE to be explained. The results show that different characteristics such as age and social class may affect consumer decision-making. The older a participant is, the more likely they are to buy energy-efficient fridges and the less likely it is that RENOVE will have any effect. This could be because older

[3] Official website: https://www.bilbaolabean.com/index.php?pag=13

people tend to have a higher economic status and could therefore invest more in EE. Social class has a negative impact on the memory effect but a positive impact on purchasing energy-efficient fridges. The decision criteria underlying the choices made in the lab experiment (e.g. energy consumption criteria, lifetime energy cost criteria, etc) also affects consumer decision-making.

Finally, the dissertation ends with an outline of the conclusions of the whole research project reported here.

1 Promoting Energy Efficiency at household level: a literature review[4]

[4] Solà, M. del M., de Ayala, A., Galarraga, I., Escapa, M., 2020. Promoting energy efficiency at household level: a literature review. Energy Efficiency 14, 6. https://doi.org/10.1007/s12053-020-09918-9

1.1 Introduction

In Europe, the household sector accounts for 36.4% of total European energy consumption (followed by industry at 29%). Energy efficiency (EE), defined as improvements in the efficiency with which energy is used to provide a service (Linares and Labandeira, 2010), is a measure proposed to reduce energy consumption. Europe is committed to an improvement in EE of at least 32.5% by 2030 according to the revised Energy Efficiency Directive (2018/2002). According to the latest report by the Coalition for Energy Savings in 2018[5], investments in EE should grow and play a key role in the years to come.

EE can lead to multiple benefits for individuals and industry, including cost reductions, decreases in GHG emissions and other local pollutants and the subsequent health benefits. However, households and business invest less in EE than what may appear economically rational, and some other EE investments do not seem economically worthwhile (Gerarden et al., 2017; Jaffe et al., 2004; Linares and Labandeira, 2010). This is an expression of the so-called *energy efficiency gap* or *energy efficiency paradox* (Jaffe and Stavins, 1994b). It is known that some of the benefits from EE investments are private (e.g. cost reductions) while others are public (e.g. GHG emissions reductions or health benefits). Corradini et al. (2014) and Markandya and Rubbelke (2012) study how environmental policies should be designed to achieve optimal EE investments by taking into account this joint provision of private and public benefits. Following the convention from previous literature, we use the term EE gap to refer to both the private and public deviations from optimality.

The high energy consumption and potential underinvestment in EE of the household sector make this one of the principal sectors that needs to reduce its associated GHG. In this context, understanding the factors that promote the EE gap is crucial to fostering reductions in energy consumption. The EE gap has been explained in terms of many reasons that can be classified in different ways. In this paper we review the factors explaining the EE gap according to the relevant literature (Frederiks et al., 2015; Gerarden et al., 2017; Jaffe and Stavins, 1994a; Linares and Labandeira, 2010; Ramos et al., 2015). These are grouped into (i) market failures, (ii) behavioural failures, and (iii) other factors.

Depending on what failure generates the EE gap, different instruments may be necessary to prevent or reduce it and promote appropriate behavioural changes to successfully nudge consumers towards more energy-efficient decisions (a review of how public policies can promote behavioural changes can

[5]More details about the report: https://www.eceee.org/all-news/news/new-analysis-member-states-must-do-more-to-meet-2030-eu-energy-efficiency-target/

be found in Cecere et al,. 2014 and D'Amato et al., 2016). The policy instruments proposed include energy standards and codes, economic incentives, feedback information and energy labelling, among others (Gerarden et al., 2017; Gillingham and Palmer, 2014; Linares and Labandeira, 2010; Markandya et al., 2015; Ramos et al., 2015). The design of EE policies depends on their objectives and those objectives can be reviewed and modified to increase their effectiveness[6]. For instance, a change in the legislation on EE labels for household appliances was accepted in 2017 (Directive 2017/1369/EU) to improve on the effectiveness of the previous label design. Additionally, EE policies could be designed with programmes fitted to regional characteristics and specificities (Borozan, 2018).

This paper focuses on the role of the EE gap in the household sector. It seeks to review the literature on the policy instruments used to promote EE and discusses their effectiveness. Several other authors have produced interesting reviews relayed to this in recent years (Linares and Labandeira, 2010; Ramos et al., 2015). Linares and Labandeira (2010) and Gerarden et al. (2017) focus on reviewing market failures and policies for addressing them, while Ramos et al. (2015) analyses both informational and behavioural failures and the policies designed to address them. This paper builds on previous literature on the EE gap at household level in order to update the evidence on the effectiveness of EE policies to address the different failures and bring updated conclusions. Updated results have been collected for example in the case price instruments.

In preparing this paper we have reviewed more than 200 papers published between 2000 and 2020[7]. Combinations of keywords related to behavioural and policy aspects were used (e.g. behaviour, EE, tax, subsidy, EE gap, failures) on SciVerse, Scopus, the Web of Knowledge and Science Direct. The findings were selected on the basis of their relevance (number of citations) with no restriction on years, although preference was given to more recent papers[8]. This procedure follows the recommendations of Berrang-Ford et al. (2015) for a review process.

The rest of the paper is structured as follows: Section 1.2 reviews and updates the literature on the EE gap. Section 1.3 presents and classifies the main policies for dealing with the EE gap while analysing their effectiveness and impact of EE policies in reducing the EE gap at European level. Finally, Section 1.4 outlines the main conclusions and the policy implications of the paper, linking the evidence reported in Sections 1.2 and 1.3.

[6]For more details, see the results of the CONSEED project: https://www.conseedproject.eu/conseed-survey-report

[7]Including some relevant and theoretical papers from the eighties and nineties (Kahneman, 1994; Kahneman and Tversky, 1984, 1979; Tversky and Kahneman, 1981).

[8] For further information see *Annex - Chapter 1.*

1.2 Households and the energy efficiency gap

The EE gap arises when a technology that may be profitable for consumers in terms of EE is available but consumers do not take advantage of it. It can be explained through different failures and factors, which are grouped in this paper into: (i) market failures (including informational failures); (ii) behavioural failures; and (ii) other factors (Bertoldi, 2020; Frederiks et al., 2015; Gerarden et al., 2017; Linares and Labandeira, 2010; Ramos et al., 2015). Table 1 presents the main failures and factors that may explain the EE gap with some of the studies in the literature that address them[9].

(i) **Market failures** include a) *informational failures;* and b) *other market failures.*

   a. *Informational failures* may refer to *asymmetric and imperfect information* (a1)*; hidden* and *transaction costs* (a2)*;* and *myopia* (a3)*.* In *asymmetric and imperfect information* (a1), markets do not reflect the real value of an investment or purchase[10]. This is common with products such as appliances or properties and is found on both the supply and demand sides (Carroll et al., 2016b, 2016a; de Ayala et al., 2016; Giraudet, 2020; Kallbekken et al., 2013; Orlov and Kallbekken, 2019). Consumers informed about EE benefits may be willing to buy more energy-efficient goods (Allcott and Sweeney, 2016; Davis and Metcalf, 2016) and owners of rental properties may invest in energy-efficient goods if they know that tenants are willing to pay more for energy-efficient buildings (Phillips, 2012). Moreover, electricity suppliers could adapt electricity supply to demand as price changes if they were perfectly aware of the price elasticity of demand[11] (Labandeira et al., 2012). *Hidden costs* (a2) refer to real costs borne by consumers that are not always taken into consideration by modellers (e.g. a lower level of energy services such as lighting quality) (Linares and Labandeira, 2010). *Transaction costs* (a2) are associated with economic transactions that could lead to a non-optimal outcome. Transaction costs are generally not accounted for in models but are real, and are especially common in the residential sector due to their combination with behavioural failures, resulting in lower investment in EE (Ramos et al., 2015; Sorrell et al., 2004). M*yopia* (a3) is usually observed when willingness to pay (WTP) for a good is not affected by changes in expected future operating costs. Under myopia, consumers do not consider reductions in future costs as benefits (Busse et al., 2013; Cohen et al., 2017; Gerarden et al., 2017).

[9] An in-depth review of the literature has been undertaken by the authors in the framework of H2020 CONSEED project. For more information see www.conseed.eu.

[10] Giraudet (2020) explains the difference between symmetric information problems and information asymmetries.

[11] Price elasticity of demand is an economic measure of the change in the quantity demanded of a good in relation to changes in its price.

b. *Other market failures* are *lower-than-efficient energy prices* (b1)*; slowness of technology adoption* (b2)*; capital market failures* (b3)*;* and the *principal-agent problem* (b4). These factors usually arise from various market externalities. For instance, investments in energy-efficient products are affected by extremely low energy prices because they do not reflect the external costs of energy and incentives to invest in EE are thus very low, as the return period for the investment becomes very long. This is known as *lower-than-efficient energy prices* (b1) (Gillingham and Palmer, 2014; Linares and Labandeira, 2010).

   Barriers to *technology adoption* (b2) also play an important role in consumer decision-making related to EE (Gilli et al., 2014; Michelsen and Madlener, 2016). The fast dissemination of new energy-related technologies is sometimes overstated (Linares and Labandeira, 2010), but some studies show that slowness of technology adoption could explain the EE gap because consumers do not consider some technologies even if they are available on the market[12] (Jaffe and Stavins, 1994b). Concerning *capital market failures* (b3), potential adopters may lack access to the capital needed to undertake EE investments. Low access to capital by consumers in lower income segments leads them to reduce their valuation of future benefits (i.e. they have a high implicit discount rate), which results in their not investing in EE (Train, 1985).

   Principal-agent problems (b4) arise when one party makes a decision with respect to EE investment but another party bears the cost or enjoys the benefits of that decision (Gillingham and Palmer, 2014). The split incentives problem, for instance, is a particular example of the principal-agent problem in the household sector: it occurs in transactions where investment and benefits are driven by different incentives between parties and do not coincide. This arises particularly with landlords and tenants, whose incentives for investing in EE may differ (Bird and Hernández, 2012; Phillips, 2012). In particular, Davis (2011) studies the landlord-tenant problem considering data from different households with US ENERGY STAR appliances and finds that renters tend to invest less in energy-efficient appliances (refrigerators, washing machines and dishwashers). Split incentives can impact tenants' behaviour as they do not usually pay energy bills directly. Maruejols and Young (2011) show that temperature settings during the day in households that do not pay directly for heating appear to be 1ºC higher than in those that do.

(ii) **Behavioural failures** include a) *inattention;* and b) *decision-making heuristics and biases*. *Inattention* (a) to future energy costs has clear implications and could potentially explain

[12] There are several potential explanations: lack of awareness by consumers of the technology (information problems), the principal agent problem or unobserved costs and other explanations that do not represent market failures (private information costs, high discount rates, etc.).

underinvestment in EE. The level of inattention among individuals may change and depends on the decision environment (Andor et al., 2016; Cattaneo, 2019; Gerarden et al., 2017). Decision-making *heuristics and biases* (b) suggest that individuals are constrained by cognitive limitations and/or bounded rationality (Cattaneo, 2019). In addition, consumers are frequently unable to process all the information required to trade-off all the alternatives in real decision-making processes (Andor et al., 2016; Blasch et al., 2019; Kahneman, 1994). This may lead them to place more value on initial costs. Reviews of behavioural failures concerning energy use and investment and waste management can be found in Cattaneo (2019) and Cecere et al. (2014), respectively.

Table 1: The main failures and factors that explain the EE gap

Failures		Factors promoting the EE gap	Literature
(i) Market failures	**a. Informational failures**	a1. Asymmetric and/or incomplete information	Allcott and Sweeney (2016) Labandeira et al. (2012) Phillips (2012) Carroll et al. (2016a) Carroll et al. (2016b) de Ayala et al. (2016) Kallbekken et al. (2013) Orlov and Kallbekken (2019) Allcott and Sweeney (2016) Davis and Metcalf (2016) Giraudet (2020)
		a2. Hidden and transaction costs	Ramos et al. (2015) Sorrell et al. (2004) Linares and Labandeira (2010)
		a3. Myopia	Busse et al. (2013) Cohen et al. (2017) Gerarden et al. (2017)
	b. Other market failures	b1. Lower-than-efficient energy prices	Linares and Labandeira (2010) Gillingham and Palmer (2014)
		b2. Slowness of technological adoption	Michelsen and Madlener (2016) Linares and Labandeira (2010) Jaffe and Stavins (1994b) Gilli et al. (2014)
		b3. Capital market imperfections	Train (1985)
		b4. Principal agent problem (e.g. Split incentives problem)	Gillingham and Palmer (2014) Phillips (2012) Maruejols and Young (2011) Bird and Hernández (2012) Davis (2011)
(ii) Behavioural failures		a. Inattention	Andor et al. (2016) Cattaneo (2019)
		b. Decision-making heuristics and biases	Andor et al. (2016) Cattaneo (2019) Blasch et al. (2019)
(iii) Other factors		a. Social norms	Liu et al. (2016) Allcott (2011) Brühl et al. (2019) Schultz et al. (2007)
		b. Procrastination	Lillemo (2014)
		c. Personal experience	Franke et al.(2012) Jensen et al. (2014)

Source: Own work adapted from Ramos et al. (2015) and Linares and Labandeira (2010).

(iii) **Other factors** can also explain the EE gap. These include a) *social norms* (Liu et al., 2016); b) *procrastination* (Lillemo, 2014); and c) *personal experience* (Franke et al., 2012; Jensen et al., 2014). *Social norms* (a) refer to the collective norms that establish what should or should not be done in a specific society. These norms can positively influence the use of heating and cooling in public buildings (Liu et al., 2016). Normative messages have mixed results in the field context (Allcott, 2011a; Brühl et al., 2019) and sometimes result in boomerang effects (Schultz et al., 2007).

Personal beliefs seem also to affect energy consumption and investment in EE. For instance, households with eco-friendly behaviour tend to invest more in energy-efficient products (Ramos et al., 2016). *Procrastination* (b), understood as the tendency to postpone tasks, is another relevant factor that could affect investment in EE. Lillemo (2014) shows that people with a tendency to procrastinate are significantly less likely to invest in energy-efficient equipment and adopt energy-saving attitudes. Finally, *personal experience* (c) also affects investment in EE. Jensen et al. (2014) show that previous personal experience with electric vehicles affects preferences and attitudes towards such vehicles.

Apart from personal factors and the failures mentioned above, other features could indirectly affect investment in energy-efficient products. For instance, *uncertainty* could make consumers decisions more complicated and may lead consumers to use heuristics. In other words, in a context of uncertainty, consumers may think in terms of expected payoffs and ignore gains and losses relative to a reference point rather than in absolute terms. Greene (2011) shows that uncertainty about fuel and electricity prices, combined with the loss aversion of buyers, results in a decision-making bias. Uncertainty can also be present at regulation level when there are frequent and unexpected policy changes (Ramos et al., 2015). Other factor that could affect the decision-making are socio-demographic characteristics (e.g. number & age of family members) and dwelling characteristics (e.g. number of bedrooms, age & size of buildings, etc.) as they could influence energy consumption (Jones and Lomas, 2015) and therefore EE investments. These characteristics may also affect the effectiveness of EE policies, as explained later in subsection 1.3.2.

1.3 Policies to address the Energy Efficiency gap at household level

Several policies have been proposed to address the failures and features mentioned previously and thus reduce the EE gap. These policies are designed to promote the purchase and adoption of energy-efficient technologies and include energy standards and codes, financial incentives, feedback information tools, audits and energy labelling (Bye and Bruvoll, 2008; Galarraga et al., 2013; Gerarden et al., 2017; Gibbons and Gwin, 2004; Gillingham and Palmer, 2014; Ramos et al., 2016). We classify the policies drawn up to date below and discuss their effectiveness based on our in-depth literature review.

1.3.1 Classification of household energy efficiency policy instruments

EE policies are classified mainly according to the purpose of each policy. In this case, our classification is based on Markandya et al. (2015) and Ramos et al. (2015).

Following Markandya et al. (2015), policy instruments can be classified into three groups: *command and control instruments* (including code and standards); *price instruments* (including taxes, subsidies, credits, permits, etc.); and *information-based instruments* (including energy audits, energy labels, smart meters, etc.).

Regarding *command and control instruments*, codes are a policy instrument that specifies how energy-efficient products must be constructed or must perform, while standards establish how a product should be constructed in order to save energy effectively (Markandya et al., 2015). Codes and standards are among the main policies for promoting the adoption of EE, and are usually implemented in industries and buildings. Such policies are commonly chosen by governments although they are considered as inflexible policies.

Price instruments include taxes, subsidies, tax deductions, credits, permits and tradable obligations. All these policies are related to fiscal incentives and are intended to encourage or discourage some decisions by consumers. Taxes and subsidies are among the most common fiscal incentives used to reduce energy consumption and GHG emissions. However, an optimal combination of subsidies and taxes seems also to be a good option (Markandya et al., 2009). Taxes are usually applied directly to energy consumption and their major effect is to generate revenues and sometimes also change energy use behaviour.

The last group comprises *informational instruments,* which are designed mainly to address informational and behavioural failures. Markandya et al. (2015) and Ramos et al. (2015) both classify these instruments into *energy certificates and labels* (Banerjee and Solomon, 2003; Bull, 2012; Chegut et al., 2014; Fuerst and McAllister, 2011), *information feedback tools* (Allcott, 2011b) and *energy audits* (Abrahamse et al., 2005; Alberini and Towe, 2015). *EE labels* are used to address the EE gap by giving more information (e.g. energy consumption, EE level) to potential customers at the point of sale. Energy labels are usually designed to help and encourage consumers to make efficient decisions, so they are designed to tackle information asymmetry and incomplete information. Labels become the cheapest and easiest way of providing consumers with EE-related information (Markandya et al., 2015). In particular, energy certificates and labels seem to be a very widespread EE policy instrument in the building and residential sectors.

Other options such as *information feedback tools* include smart meters and energy bills with comparative information. Smart meters provide households with information on how much energy appliances consume and other environmental information (e.g. health-related information, energy consumption information, CO2 emissions information, real-time pricing) and are often used to promote an efficient use of energy. In particular, energy bills with comparative information are intended to inform households of how well/badly they are doing compared to their neighbours. Apart from smart meters, there are other new technologies known as Smart Decision Support Systems (SDSS) which help consumers to make decisions in daily life regarding EE.

Energy audits, for instance, are based on an inspection to test whether a building, enterprise or household is doing its best to maximize energy savings. They are therefore usually designed to tackle informational failures and give recommendations on potential EE improvements. This policy is designed to let households know their potential for increasing their energy savings. Audits are very common in the service sector and in industry, less so in the household sector (Markandya et al., 2015).

In summary, EE labels, smart meters, information feedback tools and energy audits can be said to be designed to tackle most failures (market failures, behavioural failures and other personal factors), while price instruments are designed to deal mainly with market failures. In addition, command and control instruments such as codes and standards are designed to ensure a minimum level of adoption of energy-efficient technologies.

1.3.2 Effectiveness of energy efficiency policies

Some earlier studies have already analysed the effectiveness of EE policies using evidence from the literature (Gerarden et al., 2017; Linares and Labandeira, 2010; Ramos et al., 2015). Linares and Labandeira (2010) focus their analysis on policies that help to address market failures (e.g. taxes, subsidies) while Ramos et al. (2015) mainly focus on the effectiveness of informational instruments and Gerarden et al. (2017) look for the elements that minimise the cost of EE-related decisions. In this context, we seek to update common knowledge regarding the effectiveness of EE policies.

This section seeks to analyse the effectiveness of EE policies based on empirical studies. Given that the objective of this section is to discuss findings on the impact of EE policies in Europe, preference was given to European studies. However, some non-European studies are included to supplement the analysis of the effectiveness of EE policies since their results could be useful in designing and implementing EE policies in Europe. In fact, in the case of command and control instruments most of the papers included are non-European studies.

Tables 2A and 2B list some of the papers used to provide evidence on the effectiveness of EE policies worldwide, focussing especially on European studies. These tables also summarise the review conducted here. More than 200 papers are reviewed in total, but the sample used to give evidence in this work is limited to a selection of the most relevant among them (e.g. more recent articles). A detailed outline of all the studies reviewed is available in the form of an Excel spreadsheet[13].

- ✓ Command and control

Command and control instruments are commonly used to address market failures. It is known that these instruments, particularly codes and standards, can be hard to implement because all those agents who are unable to achieve the minimum EE levels established by the governments would have no other option than to quit the market due to their high implementation costs (Galvin, 2010; Markandya et al., 2015). In fact, Rosenow et al. (2018) review different EE obligations all around the world. The result of this global review shows that around $26 billion is invested in such instruments (10% of global annual investment in EE). Although there are cost differences among different programmes, they show that costs derived from programmes are below the typical costs of producing a kWh in most sectors and locations. Nevertheless, there are several barriers and limitations to effectively implementing codes and standards. In this regard, Lang (2004) identifies the current barriers and the challenges[14] to be overcome and proposes government funding to promote EE building improvements (e.g. improvements in heating systems) in China.

Regarding the effectiveness of energy codes, Aroonruengsawat et al. (2012) show that a significant proportion of buildings reduced their energy consumption with the introduction of residential building codes in USA. In a similar context, Jacobsen and Kotchen (2011) find decreases in electricity and gas consumption following a change in the energy building code. The effectiveness of energy codes for improving the EE of buildings is confirmed by Papineau (2017), who analyses whether commercial real estate owners are willing to pay a premium for properties with stringent energy codes in the USA. The results of this study indicate that buildings constructed under stringent building codes have a price premium of between 2.7% and 10%, and tenants are willing to pay 5.7% higher rents.

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[13] The Excel spreadsheet used for this study is available on request

[14] The vast size of the country, the temperature differences between north and south and the large number of buildings that do not comply with EE standards are just a few examples of these barriers and challenges.

Overall, command and control instruments help to reduce energy consumption and increase the price premium for buildings built under such policies. But these policies are considered as legislative or normative measures so the renovation of a building (e.g. thermal upgrades) might lead to high costs (Galvin, 2010; Markandya et al., 2015). For instance, Galvin (2010) shows for thermal upgrades in Germany a power-law relationship between the money invested and the energy saved per €. The costs of renovating to standards above a specific point (70 kWh/m2) rise exponentially while the energy saved rises a small amount.

- ✓ *Price instruments*

As shown in Table 2A, the main price instruments studied in the literature are taxes, subsidies, combinations of taxes and subsidies and rebate programmes. These instruments are commonly used to address different market and behavioural failures.

Regarding the effectiveness of taxes in improving EE in buildings, Villca-Pozo and Gonzales-Bustos (2019) show that price instruments such as property tax, personal income tax and property transfer tax, do not seem to be effective in Spain, especially in the case of old buildings. In order to overcome the apparent ineffectiveness of price instruments, authors propose to implement a rebate in the personal income tax for dwellings built before 2007.

For subsidies, Jiménez et al. (2016) show that subsidies on green cars (Plan 2000E) seem to be ineffective in promoting more energy-efficient purchases. They show that the subsidy programme leads to an increase in selling price (€600 on average in Spain), which does not encourage consumers to acquire more energy-efficient vehicles despite the subsidy.

Regarding subsidies and taxes, Galarraga et al. (2016) propose an optimal combination of taxes and subsidies for the purchase of dishwashers, refrigerators and washing machines. The optimal combination of policies depends on the goal pursued (e.g. increasing the market share of energy-efficient appliances, budget neutrality or reduction of emissions).

Governments have also introduced rebate programmes for energy-efficient products such as the RENOVE plan in Spain (Galarraga et al., 2013) and the State Energy Efficient Appliance Rebate Program in the USA (Houde and Aldy, 2017). Galarraga et al. (2013) analyse the effectiveness of the RENOVE rebate programme for dishwashers in Spain and find that it generates welfare losses, a rebound effect and a deficit in public budgets. Houde and Aldy (2017) develop a system for assessing a rebate programme for household appliances in the USA (the 2009 Recovery Act's State Energy Efficient Appliance Rebate Program). Their results show that consumers tend to buy appliances which are of higher quality but not necessarily more energy-efficient. They conclude that the long-term impact of this rebate may not lead to a decrease in energy demand. Datta and Filippini (2016) estimate an increase due to rebate policies in the sales share of “US ENERGY STAR” household appliances of 3.3 to 6.6%. Rebate programmes have also been applied to the building sector.

Regarding the effectiveness of rebate programmes for the housing sector, Drivas et al. (2019) analyse the effectiveness of an EE house retrofit programme in Greece (2011-2015). During the programme, the Greek government changed the amount of money assigned to it. This change led to an increase in the subsidy rate for lower-income households which produced an increase in EE investments by such households. Olsthoorn et al. (2017) analyse the cost-effectiveness of a rebate programme for the adoption of energy-efficient heating systems through a contingent valuation choice experiment at European level. Their results indicate that the effectiveness of the rebate is affected by the income, risk and time preferences of the recipients. They also show how weak free-riders (consumers that do not need the programme but make use of it) affect the cost-effectiveness of the rebate programme.

Finally, Jacobsen (2019) seeks to understand how EE incentives (rebates, taxes and incentives) are distributed across income groups in the United States. He shows that incentives and taxes always seem to be the policies which are concentrated most in higher-income households, while rebates are the least.

Therefore, tax and subsidies seem to have limitations when used. For instance, in developing countries fuel taxes commonly generate negative distributional effects (Markandya et al., 2015). Similarly, Sterner (2011, 2007) has shown that the main beneficiaries of fuel taxes are not the poor. Conversely, Markandya et al. (2009) show that taxes are cost-effective for boilers in Denmark and Italy, and subsidies are also cost-effective for lightbulbs in France and Poland. Finally, Panzone (2013) recommends that washing machines and TVs should be subsidised while lightbulbs and refrigerators should be taxed in the UK.

Overall, price instruments have mixed results depending on the country, the product subsidised/taxed, etc. For instance, taxes seem not to be effective for building sector in Spain as well as subsidies for the case of vehicles. In addition there might also have notable side effects such as negative distributional effects on the recipient of the incentive (Markandya et al., 2015).

The evidence on rebates is mixed; on the one hand, there is evidence that shows that rebates could lead to welfare losses and promote the rebound effect (Galarraga et al., 2013) while other studies show that rebates are effective in the USA to promote the adoption of energy-efficient technologies (Datta and Filippini, 2016).

✓ *Informational instruments*

Information-based instruments include EE policies such as energy labels, smart meters and information feedback tools and energy audits. These policy instruments are commonly designed to address behavioural and informational failures. In this section we review studies that analyse such instruments (see Table 2B). The main objective is to understand the effectiveness of such instruments in nudging consumers towards making more energy-efficient decisions.

- Energy labels

EE certificates or labels are among the most widely used EE policies. Most research on energy labels has focussed on their effectiveness when applied to housing, vehicles and appliances, which is also the scope considered here. We focus on two different types of paper: (i) studies that analyse the effectiveness of EE labels; and (ii) studies that analyse how the specific design features of an EE label affect its effectiveness and affect consumer decision-making processes. A detailed recent analysis of how the EE level of products is estimated is provided by Goeschl (2019).

For the residential market, studies generally show a positive price premium for high labelled buildings (Brounen and Kok, 2011; de Ayala et al., 2016). Indeed, de Ayala et al. (2016) estimate a price premium of between 5.4% and 9.8% for dwellings with high EE levels compared to those with lower levels. Aravena et al. (2016) show that investment in EE is driven mainly by monetary or financial factors such as potential savings, followed by comfort gains, while environmental benefits seem to be of little concern. Brounen and Kok (2011) show that buildings certified as "Green" in The Netherlands obtain a 3.7% sales premium. Also in the Netherlands, Chegut et al. (2016) show that A-rated properties in the affordable housing market obtain a 6.3% premium (compared to C-rated). Hyland et al. (2013) also find a positive sales effect in Ireland: each upwards step in the BER certificate scale leads to a price premium, with properties in the highest A-rated category having a premium of 9.3% compared to those with a D rating. Stanley et al. (2016) report similar sales premiums (1.5%) for the Dublin market in Ireland. Significant sales premiums are also observed in England (Fuerst et al., 2015), Wales (Fuerst et al., 2016) and Denmark (Jensen et al., 2016) (5%, 12.8% and 6.2-6.6% for A/B rated dwellings compared to D-rated ones, respectively).

EE improvements also affect rental properties and rents. Cajias and Piazolo (2013) show that a one percent increase in a building's energy consumption leads to a 0.08% drop in rent in Germany. In a multi-region analysis, the EC (DG Energy, 2013) finds that EE improvements are associated with a 4.4% rent increase in Austria (for a one-letter improvement: e.g. from D-rating to C-rating) and a 3.2% increase in Belgium (for a one-letter improvement). Using a discrete choice experiment, Carroll et al.

(2016a) also find that Irish renters value improvements in the Building Energy Rating (BER) of the least efficient properties (e.g. the WTP is €80/month for an improvement from an F rating to an E).

Marmolejo-Duarte et al. (2020) consider the impact of the Energy Performance Certificate (EPC) scheme in Spain and show that it has a poor reputation due to weak supervision, inaccuracies and misunderstanding of information. In order to increase the scheme's reputation and therefore is effectiveness, policy improvements are needed. Murphy (2014a) finds that only 10% of respondents in the Netherlands say that EE ratings influence their buying decision. In line with this result, Amecke (2012) also finds that EE is only a minor factor when purchasing a dwelling.

Regarding vehicles, Alberini et al. (2014) show that A-rated vehicles have a price premium of 5-11% over B-rated ones in the Swiss car market. Similarly, Galarraga et al. (2014) conclude that A- and B-labelled Spanish vehicles are sold at prices 3 to 5.9% higher than those with similar characteristics but lower EE. A recent paper explores EE labels as an instrument for promoting the purchase of energy-efficient cars in Spain (Galarraga et al., 2020), in particular, the authors analyse consumer responses to changes in vehicles prices. They find that both absolute and relative EE labels[15] could be useful depending on how consumers make their decisions.

Most of the studies that analyse EE labels for appliances conclude that there is a positive WTP for highly energy-efficient appliances. For instance, Shen and Saijo (2009) find a significant WTP for highly energy-efficient refrigerators and air conditioners in China (air conditioner 276 yuans; refrigerators 757 yuans). Similarly, Galarraga et al. (2011a) and Galarraga et al. (2011b) find that in Spain 15.6% of the final price paid for dishwashers and 8.9% for refrigerators is due to their EE level. The same authors find a WTP of between 8% and 19% for energy-efficient washing machines in the Spanish market (Galarraga et al., 2012). In line with these studies, Sammer and Wüstenhagen (2006) estimate a price premium of up to 30% for labelled washing machines in Switzerland.

A review of the effectiveness of EE labels in the USA is reported by Sanchez et al. (2008). They consider all the product categories (e.g. residential appliances) tagged with the US labelling system and conclude that the US Energy Star programme is effective but needs to be adapted to new market trends and to different products (e.g. office equipment) in order to maintain its effectiveness. In line with this argument, Davis and Metcalf (2016) test the effectiveness of providing state-specific energy price information on the EE labels of appliances. They find that consumers tend to invest more in EE in those states in the USA where energy prices are higher due to their knowledge of electricity prices.

[15] Relative labels establish EE level and fuel consumption compared with the relevant market segment, while absolute labels establish that A labelled cars consume least (these are usually small cars) and higher vehicles are rated as B or higher.

Another relevant issue regarding EE for appliances is how the conveyance of appliances (understood as "leaving the appliance behind when moving out") affects the adoption of energy-efficient products. Faure and Schleich (2020) present a survey that analyses this effect in Spain. Their findings suggest that the take-up of efficient appliances is 8% lower when they are conveyed, and that the effects on renters and owners are comparable. The results of this study could show that conveyance promotes the EE gap.

Regarding the design of EE labels, even though consumers value EE positively and there is a positive price premium for EE, Lucas and Galarraga (2015) show that consumers do not perceive differences between highly energy-efficient appliances (A++ and A+++) and A-labelled ones. They suggest that consumers may think that A-labelled appliances are efficient enough. In line with this argument, some studies have focussed on the different ways of effectively providing information on labels or on specific design features in order to better inform consumers. This is the case of the monetary label. For example, Kallbekken et al. (2013) run a field experiment with two product categories (fridge-freezers and tumble driers) to test the role of providing monetary energy-cost information through labels and through sales staff training. They find a decrease of 4.9% in the average energy use of tumble driers sold for the combined treatment (complementary labels plus staff training) and 3.4% when sales staff are trained in EE-related issues. A similar field experiment is carried out by Allcott and Sweeney (2016), who find that information and sales incentives need to be treated jointly if they are to influence consumer purchases. By contrast, Carroll et al. (2016b) conclude that the 5-year energy-cost information may not provide consumers with appropriate incentives to invest in EE.

Heinzle and Wüstenhagen (2012) conduct a discrete choice experiment and find that consumers will pay a higher price premium for televisions when ten-year monetary costs are displayed but a lower price when one-year cost information is displayed (compared to non-monetary EE information). Using an online field experiment for washing machines, Deutsch (2010) finds a small but significant reduction in average energy use (0.8%) when consumers receive additional information on life-cycle costs. In the UK, DECC (2014) finds a reduction of 0.7% in the average annual energy consumption of washer-dryers sold when lifetime energy-cost information is given to customers. However, Min et al. (2014) show that providing estimated annual energy costs has no effect on consumers' decision-making for the purchase of lightbulbs in the USA. Similarly, Allcott and Knittel (2019) find that running-cost information has no effect on car purchases in the USA. Overall, the results of the studies examined show no clear conclusions regarding the effectiveness of monetary energy labels and monetary information.

In conclusion, the literature shows that consumers have a positive WTP for energy-efficient products. Even when they value the attribute of EE positively it is not a major attribute when purchasing a dwelling. In the case of appliances, some studies also find a positive WTP but they identify a major concern of EE labels: consumers do not invest in A+++ and A++ because they think that A is efficient enough, while others find EE labels effective. In fact, the evidence show that EE labels should be adapted to new market trends in order to remain being effective. In addition, the results concerning the effectiveness of monetary labels are mixed; effectiveness is not ensured and depends on the product and country.

- Smart meters and information feedback tools

The evidence as to the effectiveness of smart meters is mixed. Carroll et al. (2014) carry out a randomised smart meter trial in Ireland and conclude that insofar as such meters work as a reminder and motivator, they are effective in terms of reducing energy demand. However, Gölz (2017) uses smart meter readings to identify energy behaviour indicators in German and Austrian households and shows that none of the feedback strategies for gaining knowledge and awareness decreases household energy consumption. The study by Rodriguez Fernandez et al. (2016) sets out to analyse big data from smart meters to design and improve EE policies. In fact, they designed a new approach with machine learning to have smart meters learning based on experience. The proposed system could contribute to reaching future energy objectives.

Information feedback tools other than smart meters seem to play a key role in promoting public awareness. Bastida et al. (2019) show that information and communication intervention-based effects on consumer behaviour could reduce final household electricity consumption by 0-5%. Casado et al. (2017) test the effectiveness of different types of information in boosting EE and find that EE messages combined with behavioural guidelines and financial benefits are more effective than those based on current consumption alone. Vassileva and Campillo (2014) show that giving feedback to families with high-energy-savings potential is effective in Sweden. Moreover, their study shows that households prefer to receive feedback by letter and via in-home displays with environmental and financial factors to save energy[16] as consumers are willing to reduce their energy consumption even if they are not interested in energy-related topics. Finally, Abrahamse et al. (2005) argue that feedback is effective in encouraging energy conservation, particularly when it is repeated over time.

[16] Compared to receiving the same information via e-mail, apps, SMS or websites.

Allcott (2011) runs a natural field experiment in the United States to test the effectiveness of sending residential utility consumers a detailed report comparing their electricity use to that of their neighbours. They observe that in the wake of the report, energy consumption decreases on average by 2%. In addition, those households in the high decile of pre-treatment energy consumption reduce consumption by 6.3%, while those in the low decile reduce theirs by 0.3%. Continuing with energy bills, Brühl et al. (2019) carry out an experiment to redesign bills (nine different bills) to test the effectiveness of the information provided. How well bills are understood is tested via a questionnaire. The results show that displaying electricity consumption with bar graphs has a positive effect on understanding, while complex graphics to explain tariff calculations are not comprehensible at all.

Using the power of social norms, Schultz et al. (2007) run a field experiment to test the effectiveness of normative messages in energy bills to promote energy conservation. They find that reporting the average energy usage of a neighbourhood generates energy savings in some households but in others has a boomerang effect. In the same vein, Asensio and Delmas (2016) carry out a field experiment on the effectiveness of smart meters using two treatments: one group received information on cost savings compared to their neighbours, the other received information on health issues. The results obtained after 9 months of control and 100 days of treatment show that health-related information could change behavioural patterns in the long run. However, cost-saving information seems able to change behaviour very fast (in the short-term), though people return to the same non-energy-saving behaviour in the long run.

Overall, the evidence reviewed shows that smart meters and information feedback tools could be effective in promoting more energy-efficient attitudes as they work as constant reminders for users. In fact, individuals and households are willing to receive recommendations in order to reduce their energy consumption even if they are not interested in energy related topics. So, smart meters could be also an effective policy to increase public awareness related to EE. However, we cannot provide general recommendations, as the effectiveness of this policy may change depending on the message (how and in what form it is provided) and the country.

- Energy audits

This effectiveness also depends on the type of audit conducted (Krutwig and Tanțău, 2018), on how the information is provided (Anderson and Newell, 2004) and on the characteristics of each household (Frondel and Vance, 2013). Krutwig and Tanțău (2018) use an innovative approach to compare the effectiveness of mandatory and voluntary energy audits in Germany between 2014 and 2016. They find that voluntary energy audits are more effective than mandatory ones. Regarding household characteristics, Frondel and Vance (2013) conclude that in Germany energy audits can have different effects depending on household characteristics such as windows, insulation, heating system or age of the household. Moreover, Murphy (2014b) finds that the impact of energy audits on EE investments in Netherlands is low. A potential explanation provided by the author is that households may think that their dwellings are efficient enough, given that a comparison between audit recipients and non-recipients shows that recipients do not tend to adopt, plan to adopt or invest more in energy-efficient technologies.

Despite these results, Alberini and Towe (2015) show that both energy audits and rebate programmes reduce energy use by 5% for heat pumps in the USA. The effects of energy audits are stronger in summer, while the rebate programme has stronger effects in winter. In a recent study based on the mandatory audit policy implemented in New York City, Kontokosta et al. (2020) show that mandatory energy audits reduce energy use by 2.5% for multifamily residential buildings and 4.9% for office buildings. However, the results of their study also show that audits do not provide sufficient incentive to invest in EE. It seems that the reduction in energy use produced by this audit policy is not sufficient to attain the carbon-reduction goals of New York City.

Another element that could affect the effectiveness of energy audits is how information is provided. Anderson and Newell (2004) find that the way in which information is provided in energy audits is crucial for promoting EE investments. In fact, audits that show shorter paybacks have higher adoption rates than those that show savings, and consumers are more responsive to initial costs than to annual savings. In line with these results, Palmer et al. (2013) find that some households find understanding energy audits of EE equipment in the USA difficult and only a tiny minority follow up the recommendations given by auditors.

The effectiveness of energy audits depends on several factors and circumstances: the country in question, how information is provided, the type of audit, etc. For instance, compulsory energy audits seem to be less effective than voluntary ones, as individuals applying these are the ones interested in EE. The conclusions derived from this section points out that while energy audits have a positive impact in USA, this policy has a low impact in Netherlands. Therefore, the effectiveness of this policy is not always ensured and further research is needed to reach a consensus.

Table 2: Effectiveness of EE policies: overview of studies and main results of command and control and price instruments (in order of appearance).

EE policy		Reference	Year of the study	Country	Sector/Product category	Methodology	Evidence on the effectiveness of the policy	Comments
Command and control	Codes	Aroonruengsawat et al. (2012)	2005-2007	USA	Appliances	Difference in Difference	+	Decrease in energy consumption
		Jacobsen and Kotchen (2011)	2000-2009	USA	Appliances	First difference regression with EPA's Energy Star data base	+	Decrease in electricity and gas consumption
		Papineau (2013)	2007	USA	Buildings	Modelling	+	Price premium: 2.7-10%
	Standards	Rosenow et al. (2018)	.	Global	.	Review	.	
		Lang (2004)	.	China	Buildings	Review	.	
Price instruments	Taxes	Villca-Pozo and Gonzales-Bustos (2019)	2018	Spain	Buildings	Modelling	.	
		Sterner (2011)	.	.	Transport	.	-	The main beneficiaries are not the poor
		Sterner (2007)	.	OECD countries	Transport	Analysis of price elasticities	-	The main beneficiaries are not the poor
	Subsidy	Jimenez et al. (2016)	2007-2010	Spain	Transport	Difference in difference	+	Subsidies lead to an increase in selling price of €600
	Combination of tax and subsidies	Galarraga et al. (2016)	2012	Spain	Appliances	Dead Wight Loss estimation	*	Optimal combination of taxes and subsidies
		Jacobsen (2019)	.	.	Appliances	Theoretical framework	.	
		Markandya et al. (2009)	2007	Europe	Household durables	Modelling	.	Boilers: taxes are cost-effective in Denmark and Italy Lightbulbs: subsidies are cost-effective in France and Poland
		Panzone (2013)	2010-2012	UK	Appliances	Modelling	*	Washing machines should be subsidised; Lightbulbs and refrigerators taxed
	Rebates	Galarraga et al. (2013)	2008-2009	Spain	Appliances	Dead Wight Loss estimation	-	effect
		Houde and Aldy (2017)	2009	USA	Appliances	Difference in difference	.	Consumers don't always buy energy-efficient appliances
		Datta and Filippini (2016)	2005-2007	USA	Appliances	Difference in difference	+	Increase in the sales share of US Energy Star appliances
		Drivas et al. (2019)	2011-2015	Spain	Buildings	Econometric model	+	Increase in the subsidy rate for lower income households
		Olsthoorn et al. (2019)	2016	EU	Heating systems	Choice experiment	*	A share higher than 50% of free-riders

+: Positive impact; -:Negative impact; .:No impact; *: No-concluding results

Source: own work. For more details see the Annex

Table 3: Effectiveness of EE policies: overview of studies and main results of information-based instruments (in order of appearance).

EE policy		Reference	Year of the study	Country	Sector/Product category	Methodology	Evidence on the effectiveness of the policy	Comments
Information based instruments	Energy labels	de Ayala et al. (2016)	2013	Spain	Buildings	Hedonic regression	+	Price premium: 5.4% - 9.8%
		Aravena et al. (2016)	2006	Ireland	Buildings	Modelling	+	Increase EE adoption by focusing on the economic benefits
		Brounen and Kok (2011)	2008-2009	Netherlands	Buildings	Logit model	+	Improvement in EE brings financial benefits
		Chegut et al. (2016)	2008-2013	Netherlands	Buildings	Hedonic real estate valuation	+	Price premium of 2.0-6.3%
		Hylland et al. (2013)	2008-2012	Ireland	Buildings	Hedonic regression	+	Price premium of 9.3%
		Stanley et al. (2016)	2009-2014	Ireland	Buildings	Hedonic regression	+	Sales premium 1.5%
		Fuerst et al. (2015)	1995-2012	England	Buildings	Hedonic regression	+	Price premium: A, B vs D: 5%; C vs. D: 1.8%
		Fuerst et al. (2016)	2003-2014	Wales	Buildings	Hedonic regression	+	Price premium: A, B vs D: 12.8%; C vs D: 3.5%
		Jensen et al. (2016)	2007-2011	Denmark	Buildings	Econometric modelling	+	Price premiums between: 6.2% & 6.6%
		Cajias and Piazolo (2013)	2008-2010	Germany	Buildings	Econometric modelling	+	Increase rent prices by 0.08%.
		Carroll et al. (2016a)	2014	Ireland	Buildings	Discrete choice experiment	+	Renters value EE positively
		Marmolejo-Duarte et al. (2020)	2016	Spain	Buildings	Discrete choice experiment	-	Poor reputation of the EPC scheme, weak supervision of the policy
		Murphy (2014a)	2008-2011	Netherlands	Buildings	Survey	+	EWE ratings influence 10% of respondents' buying decisions
		Amecke (2012)	2009	Germany	Buildings	Survey	-	EE is only a minor factor
		Alberini et al. (2014)	2010-2011	Switzerland	Transport	Hedonic regression	+	Price premium for A-rated vehicles: 5-11%
		Galarraga et al. (2014)	2012	Spain	Transport	Hedonic regression	+	Price premium for A, B rated vehicles: 3-5.9%
		Galarraga et al. (2020)	2012	Spain	Transport	Econometric modelling	*	Both absolute and relative labels could be effective depending on consumer decision-making
		Shen and Saijo (2009)	2012	China	Appliances	Survey	+	WTP for highly energy-efficient refrigerators > WTP for highly energy-efficient air conditioners
		Galarraga et al. (2011a)	2009	Spain	Appliances	Regression analysis	+	Price premium for dishwashers:15.6%
		Galarraga et al. (2011b)	2009	Spain	Appliances	Regression analysis	+	Price premium for refrigerators: 8.9%
		Galarraga et al. (2012)	2009	Spain	Appliances	Hedonic regression	+	WTP for washing machines:8-19%
		Sammer and Wüstenhagen (2006)	2004	Switzerland	Appliances	Choice experiment	+	Price premium: 30%
		Sanchez et al. (2008)	.	USA	Appliances	Review	+	
		Davis and Metcalf (2016)	2014	USA	Appliances	Choice experiment	+	State-specific labels lead to better choices

	Faure and Schleich (2020)	2016	Spain	Appliances	Survey	-	Conveyance promote the EE gap
	Lucas and Galarraga (2015)	2012	Spain	Appliances	QBDS	+	Consumers value EE positively
	Kallbekken et al. (2013)	2009	Norway	Appliances	Field experiment	+	Decrease in average energy use for tumble driers (4.9%)
	Allcott and Sweeney (2016)	2013	USA	Appliances	Natural field experiment	*	Sales incentives and monetary information should be jointly treated. Consumers tend to overestimate savings.
	Carroll et al. (2016b)	2013	Ireland	Appliances	Field experiment	*	The results do not show any statistically significant effect
	Heinzle and Wüstenhagen (2012)	2009	Germany	Appliances	Field experiment	+	Higher price premium when 10-year monetary cost is displayed
	Deustch (2010)	2006	Germany	Appliances	Choice experiment	+	Reduction in average energy use: 0.8%
	Min et al. (2014)	2010	USA	Appliances	Experiment	+	Liberal consumers → Low energy consumption lightbulbs Annual energy-cost information → Lower implicit discount rates
	Allcott and Knittel (2019)	2014	USA	Transport	Experiment	.	
Feedback	Carroll et al. (2014)	2009-2010	Ireland	Appliances	Randomised control trial	+	Feedback information is effective
	Gölz (2017)	2010	Germany Austria	Appliances	Field experiment	-	None of the feedback strategies decreases household energy consumption
	Rodriguez Fernández et al. (2016)	.	.	Appliances	Evaluation of policies	+	Analyse big data to improve EE policies
	Bastida et al. (2019)	2019	Europe	.	Modelling	+	Reduction in final energy consumption
	Casado et al. (2017)	2014	Spain	.	Experiment	+	Messages of EE + Behavioural guidelines are more effective than current energy consumption information
	Vassileva and Campillo (2014)	2011	Sweden	Energy consumption	Survey	+	Giving feedback to families with high-energy savings potential
	Abrahamse et al. (2005)	.	.	.	Review	+	Effective in encouraging energy conservation
	Allcott (2011)	2009	USA	Appliances	Natural field experiment	+	2% of energy reduction
	Brühl et al (2019)	.	South Africa	Appliances	Field experiment	+	Bar graph were comprehensible
	Schultz et al. (2007)	.	USA	Appliances	Field experiment	*	In some households the information generates energy reductions while in others a boomerang effect
	Asensio and Delmas (2016)	2011-2012	USA	Appliances	Field experiment	+	Energy savings of 8-10%
Energy audits	Krutwig and Tanțău (2018)	2014-2016	Germany	Household	Innovative methodology	+	Voluntary energy audits are more effective than compulsory ones
	Anderson and Newell (2004)	1981-2000	USA	.	Regression analysis	*	Those who received information in shorter paybacks have higher adoption rates

	Frondel and Vance (2013)	2007	Germany	Building	Mixed logit model based on German Residential Energy Consumption Survey	*	Different effects depending on the type of household
	Murphy (2014b)	2012	Netherlands	Building	Survey	-	Low impact
	Alberini and Towe (2015)	2011	USA	Building	Difference in difference approach	+	5% reduction in energy use
	Kontokoska et al. (2020)	2011-2016	USA	Building	ANOVA	*	There is a consumption reduction but not enough for achieving the objectives of NY city.
	Palmer et al. (2013)	2011	USA	Appliances	Survey	-	Not enough homeowners know about/understand energy audits

+: Positive impact; -:Negative impact; .:No impact; *: Non-conclusive results

Source: own work. For more details see the Annex.

1.4 Conclusions

Understanding how consumers make decisions related to energy use is necessary to achieve significant energy savings and reaching the European (and global) 2030 and 2050 Energy Efficiency targets. According to the revised Energy Efficiency Directive (2018/2002), an improvement of at least 32.5% needs to be made by 2030 in Europe. In this task of reducing energy consumption, the adoption of energy-efficient technologies plays a major role. Considering that the household sector is responsible for 36.4% of all European energy consumption, the promotion of EE in this sector becomes crucial.

Despite all the energy-efficient technologies available in the market, evidence shows that the adoption of such technologies is not yet the optimal one. In particular, investment in EE may not be what it seems to be economically rational. There are several failures and factors that help to explain the underinvestment in EE, such as market failures, behavioural failures and other personal factors. EE policies are being designed to address these failures and try to be effective in promoting energy-efficient technologies.

This paper discusses the effectiveness of different EE policies for the household sector based on empirical evidence in the literature. These papers can be grouped according to the failure they seek to address, i.e. market failure, behavioural failure and other factors. An in-depth review of more than 200 papers was undertaken, focussing especially on the following policy instruments: (i) command and control instruments (codes and standards); (ii) price instruments (policies such as taxes, subsidies and rebates); and (iii) informational instruments (energy labels, smart meters, information feedback tools and energy audits).

Codes and standards are set by governments and are instruments that establish how products should be constructed in order to save energy effectively. They are quite common in the USA but less so in the EU. These instruments are frequently used to address market failures and seem to be effective policies both in industry and in the household sector (especially for dwellings). However, they usually set some minimum requirements for construction. The evidence proposes government funding to overcome barriers and challenges of standards.

Price instruments such as taxes and subsidies are designed to address market failures in the household sector. While subsidies are mainly related to building renovations, taxes aim at changing the household's energy related behaviour and rebate programmes are focused on promoting the purchase of highly energy-efficient appliances. However, these price instruments do not always successfully nudge consumers towards more energy-efficient products. Taxes do not seem to be effective for the improvement of EE in the case of old dwellings and subsidies for the purchase of highly efficient vehicles but could work well for some other goods such as lightbulbs. Some studies show that the beneficiaries of price instruments tend to be wealthier people that would have bought energy efficient products anyway. In the case of the rebates nor the effectiveness nor the efficiency of this policy can be ensured. Although they can increase the number of energy-efficient appliances purchased, they can also increase the consumption of energy at home.

Informational instruments such as energy labels, smart meters and information feedback tools are commonly used in the household sector, while energy audits are less common in that sector. These instruments are designed to address informational and behavioural failures. Energy labels are used especially on almost all energy-consuming products in the household sector. They seem to be one of the most widely EE policies used for overcoming informational barriers and they generally lead to positive price premiums and reductions in energy consumption. Awareness of EE labels varies from one sector and product category to another. In general, there is some misunderstanding of EE levels and consumers may think that they are buying an efficient product when this is not the case. One way to overcome this point could be to adapt the EE label to new market trends in order to be as updated as possible. Another way would be providing monetary information which has been recently tested in the literature. The effectiveness of this labels depends on the product category, the country and the way the monetary information is provided (e.g. energy savings).

Information feedback tools such as smart meters and energy bill tools seem to be effective as they work as constant reminders to users to maintain energy-efficient attitudes. Smart meters could provide different types of information with differences in effectiveness. For instance, health related information seems to be effective in the short and long term, while monetary information seems to be only effective in the short term. The literature points out that social norms may play a role by comparing the energy consumption of a household with that of its neighbours, and could be effective in reducing energy consumption.

Energy audits are commonly used in the service and industry sectors but less so in the household sector. While businesses find energy audits useful in reducing their energy consumption, households seem to find them difficult to understand. Giving information about energy consumption in monetary terms could be helpful also in this case to understand energy audits. The type of audit seems also to be an important factor. Our evidence shows that voluntary energy audits are more effective than compulsory ones, as voluntary audits are done by households interested in improving their EE.

In this context, assessing the effectiveness of EE policies is crucial to nudge consumers towards deciding on energy-efficient products. This effectiveness could depend not only on the design of the policy but also on the failure that the policy seeks to address. This assessment plays a key role in ensuring the effectiveness of EE policies in addressing the EE gap. The more effective policies are, the more people will adopt energy-efficient products and the sooner European EE targets will be reached.

Different conclusions can be drawn from this work. On the one hand, command and control instruments seem to be effective in terms of reducing energy consumption but there are several barriers to implement them (e.g. large number of buildings that do not comply with EE standards). Regarding the effectiveness of price instruments, while subsidies and taxes do not seem to be effective, rebates presents mixed results as they are sometimes effective and in other cases, they present shortcomings such as the rebound effect. Finally, the effectiveness of informational instruments is not always ensured as depends on the sector, the users, the product category, the country and the instruments itself. The effectiveness of EE policies alone seems not to be ensured due to different shortcomings (e.g. misunderstanding of the information received). It might better work the combination of instruments such as subsidising energy audits. More research is needed to provide a better understanding of the consumer decision-making process and to learn how each type of information induces consumers to buy more energy-efficient products. Future research could hold field trials to obtain a better understanding of the effectiveness of a specific policy (e.g. monetary energy label). Related to this point, it would be also interesting to test which type of information (savings or cost) is more effective to promote the purchase of highly efficient appliances.

2 The effect of providing monetary information related to energy efficiency to consumers at the point of sale: a field experiment in Spain[17]

[17] Solà, M. del M., de Ayala, A., Galarraga, I., 2021. The Effect of Providing Monetary Information on Energy Savings for Household Appliances: A Field Trial in Spain. J Consum Policy. https://doi.org/10.1007/s10603-021-09483-3

2.1 Introduction

The production and consumption of energy is the main source of GHG emissions from the household and industry sectors in the EU-28 (Eurostat, 2018). In this context, one of the main targets and goals of EU energy policy is to increase the energy efficiency of energy-related products so as to reduce energy consumption (European Commission, 2008). Particularly, the EU seeks to achieve energy savings of at least 32.5% in all sectors by 2030 under the Energy Efficiency Directive (2018/2002).

Energy efficiency (EE) has been defined as a reduction in the energy used to provide a certain energy service or product, and it has become one of the principal instruments for reducing household energy consumption (Linares and Labandeira, 2010). Although energy efficiency can lead to several benefits such as cost reductions and decreases in carbon emissions, these are not always enough to boost investments in it. That is, even when energy efficiency may prove economically profitable for consumers, they may not always invest as much as seems rational (Gerarden et al., 2017; Jaffe et al., 2004; Linares and Labandeira, 2010). Among other reasons, this may be because consumers do not value present costs (benefits) and future costs (benefits) in the same way. In fact, consumers often fail to properly account for future costs (Allcott and Wozny, 2013; Train, 1985). This is known as the energy efficiency gap or the energy efficiency paradox: it refers to situations in which apparently beneficial investments are not made, and/or apparently non-beneficial ones are (Jaffe and Stavins, 1994a).

Economic literature has considered several explanations for the energy efficiency gap (Solà et al., 2020). These can be grouped into three categories: (1) market failures (including informational failures); (2) behavioural failures; and (3) other personal factors. "*Market failures"* is considered to mean the inefficient distribution of goods and services in a free market, "*behavioural failures"* means failures related to individuals (e.g. inattention) and "*other personal factors"* means other factors that cannot be classified under the first two headings (e.g. social norms).

Informational failures are situations in which a lack of or reduction in information could affect financial decisions. These include asymmetric and imperfect information (Allcott and Sweeney, 2016; Davis and Metcalf, 2016; Phillips, 2012), hidden and transaction costs (Ramos et al., 2015; Sorrell et al., 2004), myopia (Busse et al., 2013; Cohen et al., 2017; Gerarden et al., 2017) and uncertainty (Greene, 2011; Ramos et al., 2015; Tversky and Kahneman, 1981).

Imperfect information arises when the two parties (the seller and the purchaser) do not have the same information or when they perceive the same information differently. Hidden and transaction costs represent the tendency of purchasers to fail to perceive running costs or other costs associated with a specific product. Myopia arises when willingness to pay for a product is not affected by changes in its future operating costs. Finally, uncertainty regarding future energy prices could also affect investments in energy efficiency.

Several policy instruments can be used to cope with the different failures. They are conventionally grouped under the following headings: command and control instruments (e.g. codes and standards), price instruments (e.g. taxes, subsidies and/or a combination of the two) and informational instruments (e.g. energy labels, smart meters and information feedback tools and energy audits).

In this paper we focus on energy labels as the most commonly used instrument for addressing informational failures and reducing the energy efficiency gap. They do so by highlighting the energy efficiency level and the energy consumption of a product (Banerjee and Solomon, 2003; Carroll et al., 2016b; Heinzle and Wüstenhagen, 2012; Lucas and Galarraga, 2015). Energy labels often provide additional information such as water consumption or noise level. There are different energy efficiency labels for different product categories (e.g. cars, household appliances, etc.) and they usually contain similar but differentiated information. In particular, the energy efficiency label for appliances shows the energy efficiency level of the product, the energy consumption per year (kWh/year) and other technical attributes. For instance, along with energy efficiency level and energy consumption the label for washing machines also shows water consumption (in L), capacity (in kg), spin-cycle efficiency and noise level in the washing and spin cycles (in dB). In the case of cars however, the voluntary and comparative energy efficiency labels feature an A-G scale and additional information on running costs, annual tax costs, additional attributes of the car, etc.

Understanding the effectiveness of the energy efficiency label is crucial to successfully nudging consumers towards more energy-efficient products. Some authors have called into question the effectiveness of energy efficiency labels in recent years (Stadelmann and Schubert, 2018; Waechter et al., 2016, 2015b). Several studies show a positive willingness to pay for energy-efficient products (Galarraga et al., 2020, 2011b), but others argue that purchasers do not really properly understand the information displayed on labels (Waechter et al., 2016).

De Ayala et al. (2020) show that consumers often misunderstand the energy consumption information displayed on energy efficiency labels (see examples of EU labels in Figure 1). In particular, when focus group participants were asked to suggest potential improvements in the EU energy efficiency label, one of their suggestions was for energy consumption information to be provided in monetary terms (as well as or instead of the physical unit of kWh/year). Participants argued that having information on the operating costs would help them to decide how much they were willing to pay for more energy-efficient appliances. Moreover, some focus group participants suggested that a reference point might be shown to enable energy consumption to be compared with a view to learning whether consumption was high or not.

Several studies have analysed how providing monetary information can help consumers to better understand energy efficiency related issues (e.g. energy consumption) but there is no clear consensus on this. Some studies show that providing monetary information may be helpful in encouraging the purchase of energy-efficient products (Kallbekken et al., 2013), but others find no significant impact (Carroll et al., 2016b). In addition, the literature suggests that the effectiveness of monetary information could also change depending on the product category (Stadelmann and Schubert, 2018).

The study reported here seeks to analyse how providing monetary information on the energy efficiency of household appliances could encourage the purchase of the most energy-efficient options (A^{+++}). This is done through a field experiment that provides information on energy savings at several retailers in Spain. To that end, information on energy savings over the lifetime of a product was displayed in monetary terms (in €) for 3 types of appliance: washing machines, fridges and dishwashers. The experiment was conducted to analyse how effective providing such information may be in changing actual purchasing decisions at the point of sale. The information was displayed in three different formats: 1) using a monetary label; 2) by having sales staff that provided it; and 3) via a combination of (1) and (2). 26 small retailers participated in the experiment. They were located at various points in the Comunidad Autónoma Vasca (Autonomous Community of the Basque Country) and neighbouring regions, and belonged to the retailers Milar, Expert, Tien 21 and others. The experiment was carried out in close collaboration with two chambers of commerce in Spain (Federación Mercantil de Gipuzkoa, FMG, http://www.fmg.es/; and Confederación Empresarial de Comercio de Bizkaia, CECOBI, http://www.cecobi.es/es/portada/).

The rest of the paper is structured as follows: Section 2.2 reviews energy efficiency labelling and the literature that analyses its effectiveness. Section 2.3 presents the design of the experiment, i.e. the recruitment process, the design of the 3 different treatments and other tasks carried out during the experiment. Section 2.4 sets out all the data collected and presents some descriptive statistics; Section 2.5 presents the model specification and Section 2.6 presents the results of the experiment. Finally, Section 2.7 sets out conclusions and policy recommendations.

2.2 Current energy efficiency labels and their effectiveness

2.2.1 European energy efficiency label

Energy efficiency labels are information-based instruments used to let consumers know the energy efficiency level and annual energy consumption of a certain product. They may also show other technical characteristics such as noise level or water consumption, as per the EU Energy Labelling Directive (2010/30/EU).

Before 2010, EU labels classed the energy efficiency level of a product according to an A-G scale (with A as the most efficient level and G the least efficient). This scale was easy to understand for most (70-80%) consumers (Consumer Focus, 2012) and many people took product energy ratings into account for white-line products (Heinzle, 2012).

Due to technical and technological progress, this scale had to be updated and in 2010 a new directive was passed to change it. The EU Energy Labelling Directive (2010/30/EU) for household appliances required energy labels to be displayed on energy-related appliances at the point of sale with a scale that ranged from A^{+++} to D, in different colours (green for highly energy-efficient appliances and red for less efficient ones). Labelling schemes are usually tested after 5 years to ensure their effectiveness. In fact, Ölander and Thøgersen (2014) show that an A^{+++}-D scale is likely to reduce the effectiveness of the energy efficiency label because it leads to an anchoring effect. After a few years with this complex scale, a new regulation was passed in January 2017 to restore the original A to G energy scale. This regulation should be in force by 2021.

The energy efficiency label shows the energy efficiency level of an appliance, considering its energy consumption and many other factors such as capacity, water consumption and other technical attributes. Energy consumption information is currently displayed as the annual average in kWh. Depending on the product category, average energy consumption may be estimated differently. For example, for washing machines the average annual energy consumption is calculated during the cotton programme at 220 cycles per year (approx. 4 cycles per week) and in the case of dishwashers' consumption is calculated for the standard programme at 280 cycles per year.

2.2.2 Effectiveness of energy efficiency labels

Both the information provided and the way in which it is provided are very important in enhancing the effectiveness of the energy label and promoting energy efficiency. Several factors are really crucial for the effectiveness of energy efficiency labels: the energy efficiency scale, the colours used on the label, whether the scale is horizontal or vertical, etc. (Waechter et al., 2016). All these factors could affect the perception of consumers towards energy efficiency labels and thus affect their reliance on and the effectiveness of the policy (Waechter et al., 2016).

Several studies have analysed potential improvements in energy efficiency labels to increase purchases of appliances with higher energy efficiency levels. There is a growing body of research on how to improve labels so as to influence consumers' choices (Heinzle, 2012; Heinzle and Wüstenhagen, 2012; Noblet et al., 2006; Waechter et al., 2015b). In this context, it seems very important to understand the effectiveness of the EU labelling system and current awareness and understanding of it on the part of consumers (Tigchelaar et al., 2011; Waechter et al., 2016, 2015a, 2015b).

Substantial research has been conducted into the best way to provide energy consumption information at the point of sale. Table 4 below presents a summary of some relevant papers that have tested the effectiveness of energy efficiency scales and monetary information in different formats. For instance, some of them test the effectiveness of the EU energy labelling scale and compare the two systems (the A to G and the A^{+++}- D scales), with mixed results. Waechter et al. (2016) show that a short scale (A-C scale) could be more effective in terms of increasing energy efficiency awareness than the usual scale (A^{+++}-D scale), removing the energy efficiency level categories no longer available on the market. In addition, A-G rated appliances seem to be associated with a higher willingness to pay than those rated with an A^{+++}-D scale (Heinzle and Wüstenhagen, 2012). However, Waide and Watson (2013) find a higher willingness to pay for more energy-efficient products using an A^{+++}-D scale. These results show that consumers are willing to pay €40 more for high-labelled refrigerators.

Another relevant piece of information is whether consumers fully understand the label. In this sense, Waechter et al. (2015b) test the understanding of energy efficiency and the way in which information is plotted on the label. They show that consumers understand the concept of energy efficiency and are aware of the energy efficiency label and its scale. Despite that awareness, consumers do not always choose the most energy-efficient products as they do not pay enough attention to energy consumption.

London Economics (2014) reports an online experiment in several EU countries (Czech Republic, France, Italy, Norway, Poland, Romania and United Kingdom). That study tested different types of label (alphabetical closed scale, numerical closed scale, etc.). A benchmark that indicates the best available technology on the market is considered as a good reference point by consumers, and helps to promote energy efficiency. The same study suggests that the label scale is better understood when it is represented by letters. Moreover, no difference is found when the effectiveness of A-G and A^{+++}-D scales are compared.

Another way of plotting energy efficiency is via numerical scales, but less research has been conducted on this option. Egan and Waide (2005) show that consumers in China and Tunisia generally understand scales of these types, but find them less understandable than alphabetical scales.

Energy consumption is currently displayed as average annual energy consumption (kWh/year), and some studies point out that providing running-cost information (in €) could improve label effectiveness for appliances (Allcott and Taubinsky, 2015; Carroll et al., 2016b; Deutsch, 2010; Kallbekken et al., 2013; Stadelmann and Schubert, 2018).

Table 4: Summary of literature on EU energy label effectiveness for household appliances

Articles	Information related to energy consumption	Effectiveness of the energy scale	Other	Result
Allcott and Knittel (2017)	Annual cost information			No effect
Allcott and Sweeney (2016)			Annual savings information vs. rebates	Effective if savings information is combined with information from sales staff
Asensio and Delmas (2016)			Year cost/savings information vs. health information	Health related information is more effective
Bull (2012)			Information on losses avoided	Lifetime energy cost is effective
Carroll et al. (2016a)	5-year energy cost information			No significant impact
Deutsch (2010)	Life cycle cost information			Small reduction in energy use
Heinzle and Wüstenhagen (2012)		A^{+++}-A scale vs. A-D scale		A-D scale more effective
Heinzle (2012)			Operating costs vs. energy use	Operating costs is more effective
Kallbekken et al. (2013)	Lifetime energy cost information			Effective for tumble driers
Min et al. (2014)	Annual operating cost information			No effect
Stadelmann and Schubert (2018)	Cost and savings information			Effective for tumble driers; No effect for freezers
Waechter et al. (2015)		Energy efficiency scale vs. energy consumption		No effect, consumers do not always choose the most energy-efficient product

For example, Kallbekken et al. (2013) run a field experiment with two product categories (fridge-freezers and tumble driers) to test the effect of providing monetary energy cost information through labels and through training staff to provide monetary information. Their results show a decrease in the average energy use of tumble driers sold of 4.9% for the combined treatment and 3.4% for the staff training treatment. A similar field experiment is reported by Allcott and Sweeney (2016), who find that information and sales incentives need to be treated jointly in order to influence purchases. Similarly, Carroll et al. (2016b) run a field experiment with a 5-year energy consumption cost label for tumble driers, but find no statistically significant effects.

Stadelmann and Schubert (2018) run a field experiment to compare the effectiveness of labels in different scenarios (no label, EU Energy label and monetary energy label based on annual energy consumption) for freezers, tumble driers and vacuum cleaners. They find that the presence of either label increases sales of efficient appliances. Moreover, when these labels are used the average energy consumption (based on the consumption shown on the energy efficiency label) for tumble driers and vacuum cleaners decreases significantly, but for freezers there is no significant change, apparently due to unawareness of the new monetary energy label.

Heinzle (2012) conducts a discrete choice experiment and finds that consumers will pay a higher price premium for televisions when ten-year monetary costs are displayed but a lower premium when one-year cost information is displayed (compared to non-monetary energy efficiency information). Using an online field experiment for washing machines, Deutsch (2010) finds a small but significant reduction in energy use (0.8%) when consumers receive additional information on life cycle cost. In the UK, DECC (2014) finds a reduction of 0.7% in the average annual energy consumption as shown on the energy efficiency label of washer-dryers sold when lifetime energy cost information is given to customers. However, Min et al. (2014) show that providing estimated annual energy costs has no effect on consumers' decision-making for the purchase of lightbulbs. Similarly, Allcott and Knittel (2019) find that running cost information has no effect on car purchases in the US.

Finally, Bull (2012) carries out a stated preference survey to test what additional information is most effective for investment in energy efficiency. He finds that information about running costs and emissions increases willingness to pay and that lifetime running cost information is more effective than per annum information.

2.3 Design of the field experiment

A field experiment was conducted between February and July 2018 in cooperation with 26 small retailers in Spain to test the effectiveness of providing monetary energy savings information at the point of sale. The retailers were drawn from different Spanish autonomous regions: the Autonomous Community of the Basque Country, the Regional Community of Navarre, Cantabria and Aragón. The appliances studied were washing machines, fridges and dishwashers.

The experiment was designed in the form of three sequential treatments in some stores and business as usual in the control stores. The three treatments were: (i) adding a monetary label with lifetime energy savings information to the existing energy efficiency label (placement at visible point in physical stores); (ii) training the sales staff who provided the monetary information (but removing the aforesaid monetary label); and (iii) combining the monetary label with staff training. The three treatments were then compared to understand which might be the best strategy for effectively promoting the purchasing of energy-efficient appliances in Spain. Each treatment is explained more in detail in Subsections 2.3.1-2.3.3 below.

The suitability of these treatments was determined following earlier studies by Kallbekken et al. (2013) and Carroll et al. (2016b). Kallbekken et al. (2013) proposes a treatment with a combination of a monetary label and information from sales staff, while Carroll et al.(2016b) propose using only the monetary label. Other studies also consider using sales staff to provide information to consumers (Allcott and Sweeney, 2016). Additional qualitative research conducted under the CONSEED project also helped to effectively design the treatments (de Ayala et al., 2020). This revealed that providing detailed explanations by sales staff is a key factor. In particular, the results showed that consumers may be aware of the existence of energy efficiency labels but may not fully understand or trust the information that they provide. Consumers tend to rely more on the information and advice provided by sales staff.

To cover all the evidence mentioned, we decided to test the effectiveness of providing monetary information through three sequential treatments: adding a monetary label (Treatment 1), having sales staff provide monetary information (Treatment 2) and a combination of the two (treatment 3). We decided to implement sequential treatments in order to ensure a significant number of observations per treatment. This enables us to see which treatment is potentially the best for promoting the adoption of highly energy-efficient appliances in Spain. Table 5 gives a description and the timeline of each treatment in the experiment.

Table 5: Description of treatments

	Treatment 1	**Treatment 2**	**Treatment 3**	**Control**
Description	Monetary label showing lifetime energy savings in €	Information from sales staff	Monetary label showing lifetime energy savings in € + Information from sales staff	Business as usual
Period	5th February – 4th April 2018	5th April – 3rd June 2018	4th June – 31st July 2018	5th February – 31st July 2018
Number of stores	14 stores in the treatment group from the Autonomous Country of the Basque Country (11), Cantabria (1), Aragón (1), Navarre (1)			12 stores in the control group from the Autonomous Country of the Basque Country (8), Aragón (2) and Navarre (2)

Retailers were recruited through two chambers of commerce and business federations: (1) the "Federación Mercantil de Gipuzkoa (FMG)" located in the Spanish province of Gipuzkoa; and (2) the "Confederación Empresarial de Comercios de Bizkaia (CECOBI)" located in the province of

Bizkaia. These are non-profit associations set up to defend the interests of companies and small retailers. They act as lobby groups with the public administration.

Kick-off meetings with these organisations were held in July and October 2017 to explain the main characteristics of the study and collect their feedback. A second meeting was held in October 2017 to share full details of the experiment (e.g. the different designs of the proposed field experiment & its timeline). FMG then conveyed this information to all the small retailers in their network and recruited volunteer stores in Gipuzkoa to participate in the field experiment. CECOBI also provided access to potential volunteer stores in the Autonomous Community of the Basque Country, the Regional Community of Navarre, Cantabria and Aragón (four of Spain's 17 autonomous regions).

Each participating retailer was visited in November 2017 for a face-to-face meeting to explain the field experiment design in detail and respond to any questions or issues. Engaging with retailers proved crucial for the success of the field experiment because it enabled us both to build the necessary trust and to improve the design of the experiment based on their expertise.

The small retailers participating were assigned to each group (treatment or control group) based on their geographical location (provinces), the size of cities (small, medium and large) and their sales volumes in previous months. This was done to ensure that the control and treatment groups were as similar as possible (see Table A1 of *Supplementary information for Chapter 9* for further details on retailer characteristics).

As a result, 12 retailers were assigned to the control group and 14 to the treatment group. In January 2018, we contacted all the retailers to explain their roles in the field experiment, the timeline of the experiment and the different tasks that it would entail.

2.3.1 Adding a monetary label (treatment one)

The first treatment started on February 5th and ended on April 4th (see Table 5). It consisted of placing a monetary label close to the mandatory energy efficiency energy label which must be affixed at a visible point on all household appliances in the corresponding stores. This label showed energy savings information in monetary terms (in €) for each specific appliance. Consumers thus had information on the energy consumption of the appliance as well as on likely energy savings in monetary terms. The savings for each appliance were calculated in comparison to the similar appliance with the highest annual energy consumption (see subsection 2.3.2 for more details). It is important to note that sales staff did not receive any specific training and were not required to highlight the information displayed on the label. That is, they were instructed to behave just as they did before the monetary label was available.

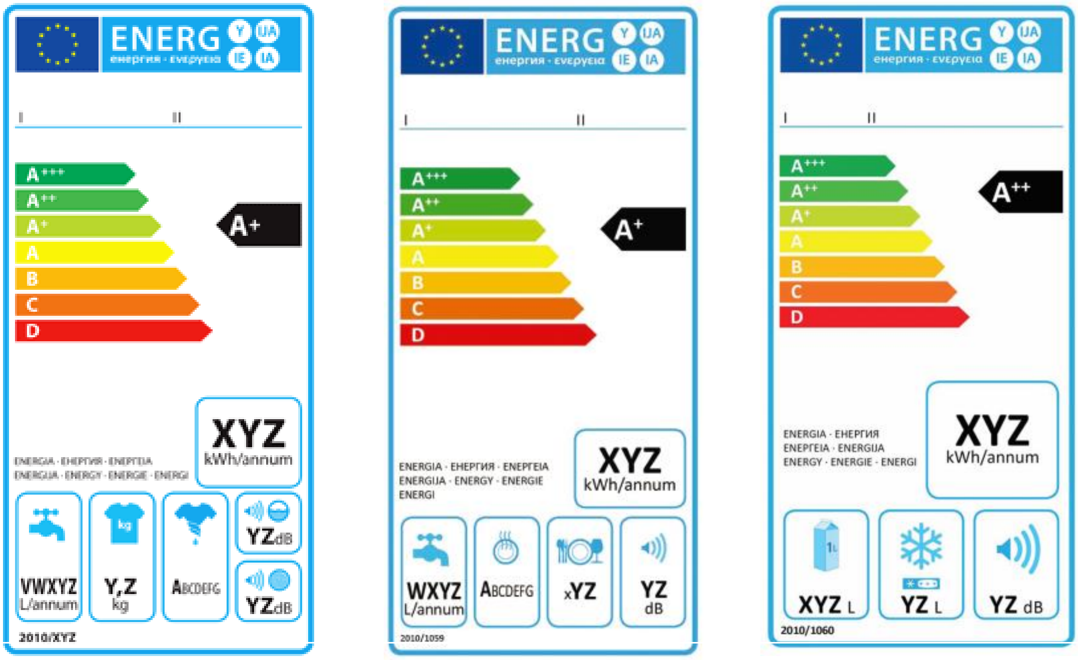

Figure 1: EU energy efficiency labels for washing machines, dishwashers and fridges

2.3.2 Design of the monetary label

Following advice from the two chambers of commerce consulted, preference was given to presenting information on *energy savings* rather than information on *energy costs* in the monetary label. The main reason for this was that small retailers preferred energy savings information to motivate sales with positive messages and to avoid any possible confusion with other cost concepts such as the price of the appliance.

On that basis, the monetary label shown in Figure 2 was designed for each appliance to be used in the field experiment.

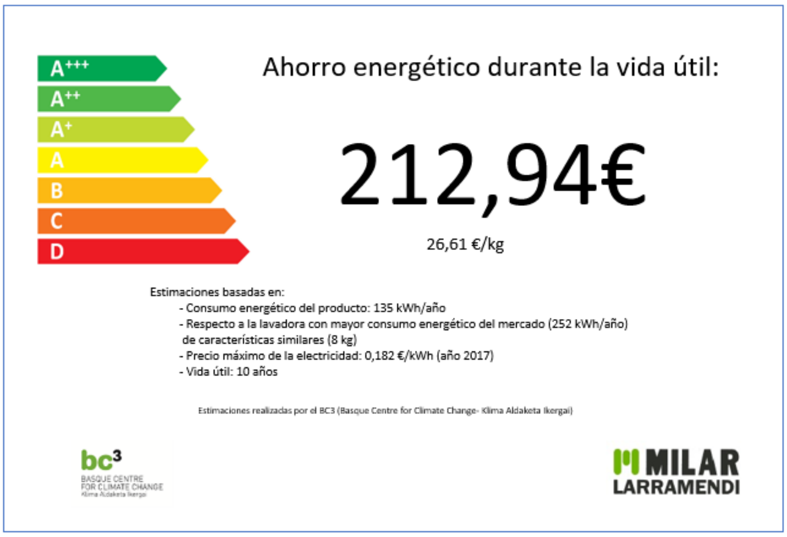

Figure 2: Monetary label used in the field trial (in Spanish): example for a washing machine with an energy consumption of 135 kWh/year (English translation: "Lifetime energy savings: €212.94. Estimates based on: (i) energy consumption of the product: 135 kWh/years".)

✓ Estimating lifetime energy savings

One of the main challenges was calculating the lifetime energy savings for each appliance. First, we created a database with all the stock available (fridges, washing-machines and dishwashers) at each of the retailers taking part, specifying types of appliance, energy efficiency levels, energy consumption and other technical attributes.

Based on that database, the following formula was used to estimate the lifetime energy savings (LES) following Stadelmann and Schubert (2018):

$$LES = (MEC - EC) * ep_{2017} * L,$$

where MEC is the maximum energy consumption for that product category, EC is the energy consumption of a specific product, ep_{2017} is the maximum energy price in 2017 and L is the lifetime of the product. Thus, we estimated the MEC for each product category with similar characteristics. For example, to estimate lifetime energy savings for an 8 kg-load washing machine, the MEC chosen was the maximum energy consumption of a washing machine with that load capacity.

An important issue when estimating lifetime energy savings is the energy price considered. We considered the maximum energy price recorded in Spain in 2017[18]. For product lifetime, suggestions made at our meetings with small retailers and experts led us to use a figure of 10

[18] Red Eléctrica Española publishes all the data for PVPC (*Precio Voluntario para el Pequeño Consumidor* – Voluntary Price for Small-scale Consumers) on the Spanish market on this website: https://www.esios.ree.es/es/pvpc. We chose the highest energy price recorded because it was closer to the real price that consumers were paying.

years for appliances, as this seems to be the average in Spain (Organización de Consumidores y Usuarios, 2020).

The colour scale from the official European energy efficiency label was maintained to link the current EU energy efficiency label with the monetary label proposed (left-hand side of the monetary label in Figure 2) and because this scale seems to be understandable and familiar to households (de Ayala et al., 2020). The logos of the research centre leading the experiment and the various retailers taking part were shown at the bottom of the label. This was a way of demonstrating that the calculations and information provided were officially backed by a research organisation. In no case were consumers informed that the labels were part of a field experiment or research project, so as not to bias the purchasing decision-making process.

Table A2 (in *Annex-Chapter 2*) shows the average lifetime energy savings for each product category.

2.3.3 Sales staff provide monetary information (treatment two)

The second treatment ran from April 5th until June 3rd (see Table 5). In this treatment, sales staff provided potential consumers with information related to energy savings for each appliance under study. The aim was to gain an understanding of the role of sales staff in guiding and nudging consumers' purchasing decisions towards more energy-efficient appliances. Staff training was designed to teach several aspects of energy efficiency in regard to the products under study, including the main concepts, and general knowledge of energy efficiency (see Appendix S2 in *Annex- Chapter 2* for the whole list of topics taught). Other points taught included how energy efficiency levels are calculated and the assumptions under which the energy consumption of a product is calculated[19].

The sales staff were familiarised with how lifetime energy savings are estimated under each product category. During this treatment the monetary label from treatment one was not visible, i.e. information on lifetime energy saving was provided solely by the (trained) sales staff.

[19] To measure the energy consumption of an appliance, certain baseline assumptions were made. In the case of the three products under study, the assumptions were as follows: washing machine - 220 cycles per year and cotton programme (45º and 60º); dishwasher - 280 cycles per year and standard programme (65º); fridge - 24/7 use.

2.3.4 Combination of monetary label with information from sales staff (treatment three)

The third treatment began on June 4th and ended on July 31st (see Table 5). It consisted of a combination of the two previous treatments, i.e. the monetary label and the explanations from sales staff (based on the training received). During this treatment, the retailers taking part again placed the monetary label next to the official one but also provided energy savings information to guide purchasing decisions based on the training received.

2.3.5 Support and follow-up

To ensure that all sales staff and retailers were carrying out the tasks for each treatment and to try to avoid any mental fatigue on the part of salespeople, weekly telephone calls were made by the researchers. During the first treatment, they were reminded that the monetary label should be placed next to the official European energy efficiency label. Retailers were also asked about the appliances available in the shop so that we could prepare the corresponding monetary labels and send them via express delivery. The model of the product for which it was intended was written on the back of each label prepared, to ensure that labels were correctly placed in the store.

During the second treatment, retailers received a document prepared with all the information from the training and the calculations of lifetime energy savings made for each product category for consultation if necessary. We also spoke with the retailers via WhatsApp and by telephone to ensure that they provided the information in the correct way.

In the last treatment, we asked about stock numbers to reprint sufficient monetary labels. Regular calls were also made to ensure that all products had the monetary label in place (next to the official one) and to respond to any queries.

2.4 Data

In total 26 retailers took part in the experiment: 14 of these were assigned to the treatment groups and 12 to the control group (see Table 5). The retailers are located in the northern part of Spain: 19 stores are in the Basque Autonomous Country and the regional communities of Aragón (3 stores), Navarre (3 stores) and Cantabria (1 store).

The retailers provided us with the following information: date of sale, type of appliance sold, model of the product, price of the product and whether there was any price discount on the product at the time. We merged these data with an internal database with some technical attributes of each appliance (e.g. capacity of the product, water consumption). Our internal database contains the technical attributes of each appliance type and model. In the case of washing machines, we collected information on capacity (in kg), type of embedding and water consumption (in L) for each model. For fridges we collected information on fridge and freezer volumes (in L), type of embedding and type of fridge. Finally, for dishwasher's information on width (450 mm or 600 mm), number of services, type of embedding and water consumption (in L) was collected. Table 6 shows all the data collected together with the sources.

Short surveys were also designed to obtain key socio-demographic information on the consumers buying the appliances in question. These included questions on gender, home post code and age range (see the questionnaire used in Figure A1 in *Annex-Chapter 2*).

Customers' post codes enabled us to use the data on income per capita at municipality level provided by regional statistics offices[20]. In the case of large cities, different post codes enabled us to obtain information on income per capita.

[20]Income information on each municipality is available from the following sources: for the regional community of Aragón (IAEST), for the Regional Community of Navarre (Instituto de Estadística de Navarra); for the Cantabria región (Instituto Cántabro de Estadística); and for the Autonomous Community of the Basque Country (Instituto Vasco de la Estadística).

Table 6: Data and sources

Data collected	Source
Date of sale	Small retailer
Place of sale	Small retailer
Type of appliance sold	Small retailer or internal database
Brand of the appliance sold	Small retailer or internal database
Model of the appliance sold	Small retailer
Energy efficiency level of the appliance sold	Internal database
Energy consumption of the appliance sold	Internal database
Specific and technical attributes of the appliance sold	Internal database
Price of the product sold	Small retailer
Discount on the product sold	Small retailer
Socio-demographics: • Gender • Age range • Post code	Small retailer

However, some data limitations were encountered. For instance, we were unable to obtain specific information on consumers such as the real income of each consumer or their previous purchasing experience (e.g. first-time buyers). Nor could data regarding brand loyalty or the individual preferences of consumers be gathered.

The internal database was prepared with information on the attributes of appliances for each model. In the case of washing machines, we collected information on the capacity (in kg), type of embedding and water consumption (in L) of each model; for fridges we collected information on fridge and freezer volumes (in L), type of embedding and type of fridge. Finally, for dishwashers we collected information on width (450 mm or 600 mm), number of services, type of embedding and water consumption (in L).

For the appliances sold in the stores, Figure 3 shows the percentages of products sold by the treatment and control groups per product category (washing machines, fridges and dishwashers) and energy efficiency level (A^{+++}, A^{++} and A^{+}). The vast majority of washing machines sold in the treatment and control groups were A^{+++}. In the treatment group, A^{+++} washing machines accounted for 92.64% of the total and in the control group for 91.05%. In the case of fridges, the proportion is different: the most energy efficient level sold was A^{++} (44.48% in the treatment group and 55.43% in the control group). Finally, for dishwashers A++ and A+ each accounted for 42.86%. The average selling price per product category and appliance is shown in Table A3 in *Annex-Chapter 2*.

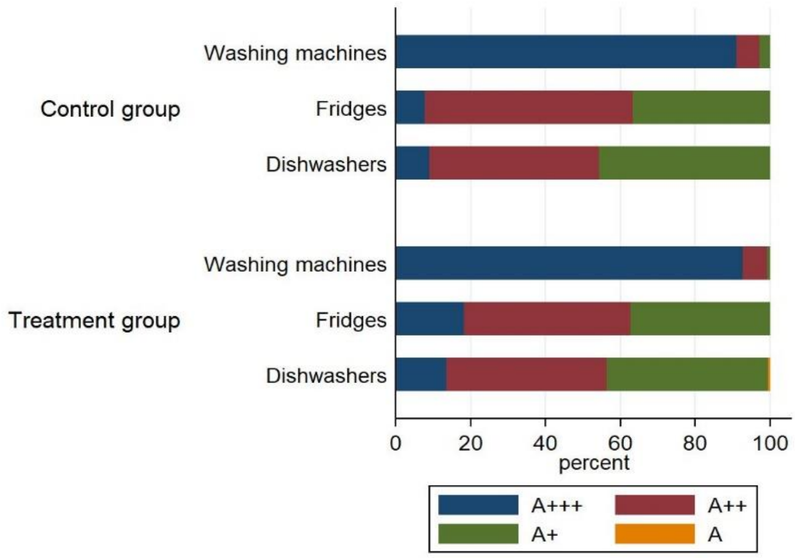

Figure 3: Percentage of appliances sold per energy efficiency level during the experiment in the control and treatment stores

Table 4 shows the percentage of appliances sold during the experiment per product category, brand, gender and age range. The product sold most was washing machines, which accounted for 51.63% of the sales, followed by fridges (31.51%) and dishwashers (16.86%). As regards brands per appliance, for washing machines two brands predominated: Bosch (16.39%) and AEG (13.51%). No other the brand (e.g. Siemens, Samsung, Miele) accounted individually for as much as 10% of sales. For fridges the biggest-selling brand was Bosch at 15.88% of sales, followed by Siemens (10.96%) and Liebherr (10.86%). Finally, for dishwashers there were many brands which accounted for more than 10% of sales: Bosch was the biggest seller at 15.33%, closely followed by AEG (15.13%) and Balay (14.56%).

The vast majority of purchasers were women. Moreover, the biggest proportion of purchases was made by consumers between 46 and 60 years old: 44.01% for washing-machines, 40.57% for fridges and 40.80% for dishwashers).

Table 7: Percentage of appliances sold per product category, brand, gender and age range

Sales during the experiment	Washing machines	Fridges	Dishwashers
Observations	1599	976	522
%	51.63%	31.51%	16.86%
Sales during the experiment by brand	**Washing machines**	**Fridges**	**Dishwashers**
1st brand	Bosch (16.39%)	Bosch (15.88%)	Bosch (15.33%)
2nd brand	AEG (13.51%)	Siemens (10.96%)	AEG (15.13%)
3rd brand		Liebherr (10.86 %)	Balay (14.56%)
Rest	Rest (<10%)	Rest (<10%)	Rest (<14%)
Gender of purchaser	**Washing machines**	**Fridges**	**Dishwashers**
Male	658 (41.15%)	459 (47.03%)	248 (47.51%)
Female	934 (58.41%)	515 (52.77%)	273 (52.30%)
Both	7 (0.44%)	2 (0.20%)	1 (0.19%)
Age range of purchasers	**Washing machines**	**Fridges**	**Dishwashers**
18 - 30 years	28 (1.76%)	21 (2.15%)	12 (2.30%)
31- 45 years	388 (24.33%)	228 (23.36%)	138 (26.44%)
46 – 60 years	703 (44.01%)	396 (40.57%)	213 (40.80%)
More than 60 years	477 (29.91%)	331 (33.91%)	159 (30.46%)

2.5 Model specification

We use binary response models to analyse the data, so the dependent variable only takes a value of zero or one. These models are specified as follows:

Assume that $y^*$is a latent variable which follows $y^* = X\beta + e$, where X is the $1 \times K$ vector, β is a $K \times 1$ vector of parameters, e is independent of X and $e \sim$ Normal (0,1).

However, instead of y^*, only a binary variable indicating the sign of y^* is observed:

$$y = \begin{cases} 1 & if\ y^* > 0 \\ 0 & if\ y^* \leq 0 \end{cases} \tag{1}$$

In binary response models, the interest lies in the response probability:

$$P(y = 1 \mid X) = P(y^* > 0 \mid X) = P(e > -X\beta \mid X) = 1 - G(-X\beta\,) = G(X\beta\,) \equiv p(x)$$

where G is the cumulative distribution function of a standard normal density function (called a probit model). G can also be the cumulative distribution of a logistic function (a Logit model).

For this study, the probit model can be expressed as $P(y = 1 \mid X)$, where y is the energy efficiency level and X contains explanatory variables referring to how monetary information is provided by *treatments* (see Table 2) plus the technical *attributes* specific to each appliance type (e.g. size, type of embedding and water consumption) and *socio-economic* characteristics (e.g. income):

The choice of the dependent variable *y* is based on the percentage of appliances sold per energy efficiency level during the experiment period. For washing machines, most sales were A^{+++}, while for fridges and dishwashers most were A^{++}(see Figure 3). Given that the objective of this study is to nudge consumers towards high energy-efficient products, we seek to determine whether the treatments are successful in nudging purchasers towards A^{+++} choices for washing machines and fridges and towards A^{+++} and A^{++} for dishwashers (for more details on the distribution of energy efficiency levels per appliance see Figure A2 in *Annex-Chapter 2*). We first run a model with explanatory variables but no interaction effects, and then another interacting some treatments with other explanatory variables (e.g. Treatment 1 and price). Finally, we choose the one whose interaction effects are most significant for each appliance. Thus, for each type of appliance we estimate different models that reflect the probability of buying a highly energy-efficient appliance depending on the treatments, technical attributes, socio-economic factors and some interaction effects. Specification (2) refers to the model for washing machines, (3) for fridges and (4) for dishwashers:

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Trat1 + \beta_3 Trat2 + \beta_4 Trat3 + \beta_5 Capacity + \beta_6 TypeofEmbedding + \beta_7 WaterConsumption + \beta_8 Price + \beta_9 Trat1 * Price + \beta_{10} Trat2 * Price + \beta_{11} Trat3 * Price + \beta_{12} Income + \beta_{13} Income^2 + \beta_{14} Trat1 * Income + \beta_{15} Trat2 * Income + \beta_{16} Trat3 * Income + e, \quad (2)$$

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Trat1 + \beta_3 Trat2 + \beta_4 Trat3 + \beta_5 VolumeFridge + \beta_6 VolumeFreezer + \beta_7 Price + \beta_8 Trat1 * Price + \beta_9 Trat2 * Price + \beta_{10} Trat3 * Price + \beta_{11} Income + \beta_{12} Income^2 + \beta_{13} Smallcity + \beta_{14} Bigcity + \beta_{15} AgeUnder30 + \beta_{16} AgeBetween30and45 + \beta_{17} AgeOver60 + e, \quad (3)$$

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Trat1 + \beta_3 Trat2 + \beta_4 Trat3 + \beta_5 Width + \beta_6 NumberServices + \beta_7 WaterConsumption + \beta_8 Price + \beta_9 \mathrm{Trat1} * \mathrm{Price} + \beta_{10} \mathrm{Trat2} * \mathrm{Price} + \beta_{11} \mathrm{Trat3} * \mathrm{Price} + \beta_{12} \mathrm{Income} + \beta_{13} \mathrm{Income}^2 + \beta_{14} Smallcity + \beta_{15} Bigcity + + \beta_{16} Trat1 * Income + \beta_{17} Trat2 * Income + \beta_{18} Trat3 * Income + \beta_{19} AgeUnder30 + \beta_{20} AgeBetween30and45 + \beta_{21} AgeOver60 + e, \quad (4)$$

where *y* takes a value of 1 if the energy efficiency level is A^{+++} for washing-machines and fridges and A^{+++} and A^{++} for dishwashers, and 0 otherwise. *Trat1* takes a value of 1 if the appliance was sold during Treatment 1 and 0 otherwise, *Trat2* takes a value of 1 if the appliance was sold during

Treatment 2 and 0 otherwise and *Trat3* takes a value of 1 if the appliance was sold during Treatment 3 and 0 otherwise.

The attributes included for washing machines (see equation (2)) are as follows: $Capacity$ is a numerical variable that captures the capacity of each washing machine sold during the experiment. $TypeofEmbedding$ takes a value of 1 if the washing machine has free installation and 0 otherwise. $WaterConsumption$ and $Price$, are numerical variables that indicate the water consumption and price respectively of each washing machine sold during the period under study.

As equation (3) shows, in the case of fridges just three numerical variables represent the technical attributes: $VolumeFridge$ (the volume of the fridge), $VolumeFreezer$ (the volume of the freezer) and $Price$ (price of the fridges sold during the experiment).

In the case of dishwashers (see equation (4)), four technical attributes were considered: $Width$ (a value of 1 if the dishwasher is 600 mm wide and 0 otherwise), $NumberServices$ (a numerical variable reflecting the number of services by the dishwasher), $WaterConsumption$ and $Price$ (numerical variables indicating the water consumption and price of the dishwasher sold, respectively).

The socio-economic variables included in equations (2), (3) and (4) are: *Income* (the average income for the post code area of the purchaser of the appliance in question), the size of the city where the purchaser lives and their age. City size is captured via two variables (criteria shown in Table A1 in *Annex-Chapter 2*): $Smallcity$ (a value of 1 if the city is small) and $Bigcity$ (a value of 1 if the city is big). The age of purchasers is factored in via $AgeUnder30$ (a value of 1 if the purchaser of the appliance is less than 30 years old), $AgeBetween30and45$ (1 if the purchaser is aged between 30 and 45) and $AgeOver60$ (1 if the purchaser is over 60).

The rest of the variables are interactions of the variables defined above. For instance, $Trat1 * Price$, is the interaction of the variables *Trat1* and *Price*. This interacted variable is interpreted as the impact of the price during Treatment 1 (information on energy savings is provided through a monetary label) on the probability of buying a high energy-efficient appliance. Similarly, $Trat2 * Price$ is interpreted as the impact of the price during Treatment 2 (information on energy savings is given by sales staff) on the probability of buying a highly efficient appliance. The rest of the interacted variables are defined and interpreted in the same way.

Table A4 (in *Annex-Chapter 2)* presents the descriptive statistics for the explanatory variables included in the three specifications (equations (2), (3) and (4)). Note that the variables should be standardized in order to avoid multicollinearity.

2.6 Results and discussion

The three probabilistic models (2), (3) and (4) were estimated using STATA Version 16. Table 8 presents the marginal effects of the explanatory variables for all the appliances on the probability of purchasers acquiring an appliance labelled with high energy efficiency, A^{+++} (for washing machines and fridges) and A^{+++} and A^{++} for dishwashers.

2.6.1 Effect of Treatments

Table 8 presents the marginal effects of the different treatments and the explanatory variables on the probability of buying a high energy-efficient appliance. The effectiveness of treatments varies from one product category to another. For washing machines, Treatment 1 (the monetary label) is effective in terms of promoting the purchase of high energy-efficiency appliances (i.e. A^{+++} washing machines). That is, the presence of the monetary label seems to increase the probability of buying an A^{+++} washing machine by 3.16% compared to the control group (no intervention). As can be seen in Table 8, Treatment 2 (information given by sales staff) and Treatment 3 (information given by the monetary label and by sales staff) seems not to be statistically significant in increasing the purchase of A^{+++} washing machines.

For fridges, Treatment 2 (intervention of sales staff) and Treatment 3 (intervention of sales staff combined with the monetary label) seem to increase the probability of investing in high energy-efficient fridges (A^{+++}) with respect to the control group (no intervention, business as usual). In addition, note that Treatment 2 seems to be more effective than Treatment 3 (by 11.5%). This finding may be counterintuitive, as Treatment 3 might be expected to be more effective than Treatment 2. One possible explanation for this may be the so-called "mental fatigue". Although stores were regularly reminded by telephone of how they should provide customers with information on energy savings, small retailers may have tired of interacting in the way suggested by the research design as the experiment ran for six months.

Finally, in the case of dishwashers none of the treatments seems to be effective in promoting the purchase of high energy-efficiency dishwashers (A^{+++} and A^{++}). One explanation could be that consumers are not so worried about energy efficiency in the case of dishwashers as they are for fridges and washing machines. This makes sense if the way in which each appliance is generally used is taken into account. A second explanation could be that not all households have dishwashers as they do not consider them to be a necessary appliance. In fact, the number of dishwashers purchased during the field experiment is significantly lower (16.86%) than the numbers of washing machines (51.63%) and fridges (31.51%).

The effectiveness of treatments thus differs according to the product category. Treatment 1 (monetary label) is effective for washing machines, while Treatment 2 (sales staff) and Treatment 3 (combined treatment) are effective for fridges, and none of the treatments is effective for dishwashers. These heterogeneous results are consistent with the literature on the effectiveness of monetary information in promoting the purchase of highly efficient appliances. Kallbekken et al. (2013) report that monetary information was effective for tumble driers but not for freezers. Stadelmann and Schubert (2018) obtained similar findings for the same products and Carroll et al. (2016b) found no significant effect for tumble driers.

2.6.2 Attributes

Some differences were observed among the appliances under study in terms of attributes. The results for washing machines show that the type of embedding and the capacity (kg) of machines increase the probability of buying an A^{+++} machine and can thus be seen as determinant in influencing the purchasing decision. By contrast, the greater the water consumption of a washing-machine is, the less likely it is that a high energy-efficiency machine will be purchased. At this point, it is important to remember that the energy efficiency level of a specific washing machine takes into account not only its energy consumption but also other attributes such as water consumption.

When Treatment 1 is combined with price for washing machines, the resulting variable is statistically significant and negative. This may indicate that in the presence of Treatment 1 (the monetary label), the price may reduce the probability of consumers buying a high energy-efficiency (A^{+++}) washing machine. That is, the higher the price the smaller the probability of investing in an A^{+++} when the monetary label is displayed (Treatment 1) for washing machines.

For fridges, the analysis shows that volume (in L) and price (in €) seem to have positive impacts on the probability of buying a highly energy-efficient unit (A^{+++}). This is in line with the descriptive statistics on prices: the average price of A^{+++} fridges is €956.52 while the average price for A^{++} is €704.81 (see Table A3 in *Annex-Chapter 2* for more details of the average prices for each product category).

In the case of dishwashers, the size of the product, the number of services and the water consumption attributes are significant. In particular, the width of the product (450 mm or 600 mm) and the number of services have a positive sign, i.e. the bigger the product or the more services it provides the more likely people are to buy a high energy-efficiency dishwasher. Water consumption has a negative impact, i.e. the higher it is the lower the probability of buying a high energy-efficiency (A^{+++} and A^{++}) is. A surprising result is that price is not statistically significant despite a substantial difference between the average price of A^{+++} and A^{++} dishwashers (€705.71 and €483.24, respectively). The interacted variable of Treatment 3 combined with price also has a positive impact. This means that the price during Treatment 3 (the combination of the monetary label and information from sales staff) has a positive impact on the probability of buying an A^{+++} dishwasher. In other words, the higher the price during treatment 3, the more likely people are to buy an A^{+++} dishwasher. This may indicate that high-efficiency appliances are usually the most expensive ones.

Our results are in line with the literature. For washing machines attributes such as price, spin speed, depth and capacity are relevant in the decision-making process (Galarraga et al., 2012), while for fridges efficiency, volume, embedding, colour and defrosting capacity seem to be significant (Galarraga et al., 2011b). For dishwashers brand, efficiency level, drying efficiency, number of services and width seems to be the most important factors (Galarraga et al., 2011a).

2.6.3 Socio-economic factors

The various socio-economic variables have different impacts from one appliance to another. For example, the effects of age are heterogeneous. For fridges people aged between 30 and 45 tend to invest less in high energy-efficient fridges; if the buyer is over 60 years old the probability of buying a high energy-efficient dishwasher seems to decrease. It is not rare to find this age effect, under which older people (especially those beyond a certain age) may tend to invest less in EE. Age could play a significant role in deciding whether to invest in energy efficiency or not, maybe because older buyers are less certain that they will recover their initial investment. Age plays a significant role in energy efficiency investment and in fact, according to the literature, willingness to pay for energy efficiency declines when the consumer is over 55 (Zarnikau, 2003). The rest of the socio-demographic variables included in the regressions, e.g. small city and big city, are not found to be significant in the analysis. This may indicate that investment in energy-efficient dishwashers is not affected by where consumers live.

The interaction between Treatment 3 and Income is statistically significant but differs in its sign between washing machines and dishwashers. When Treatment 3 (the combination of the monetary label and information from sales staff) is applied, higher income purchasers are found to be more likely to buy an A^{+++} washing machine. The effect is small, but income seems to determine whether people invest in energy-efficient washing machines. The same interacted variable has a negative impact in the case of dishwashers, i.e. the higher the income of consumers is, the less likely they are to buy an A^{+++} dishwasher.

The literature reports that there is a strong correlation between income and energy efficiency investment (Zarnikau, 2003). In fact, liquidity and credit constraints could affect investment in high energy-efficiency products, as in general purchasing highly efficient appliances requires an additional investment that may not be affordable for all consumers (Filippini et al., 2020). In our study we find that A^{+++} fridges are on average €251.71 more expensive than A^{++} fridges. This could explain why people aged between 30-45 invest less in highly efficient fridges. Consumers in this age are likely to be “baby-boomers” and probably have less income available to invest in energy efficiency (Filippini et al., 2020; Zarnikau, 2003). This could help explain the so called energy efficiency gap.

Table 8: Marginal effects for washing machines, fridges and dishwashers

Washing machines		Fridges		Dishwashers	
VARIABLES	**Marginal effects**	**VARIABLES**	**Marginal effects**	**VARIABLES**	**Marginal effects**
Treatments		**Treatments**		**Treatments**	
Control	--Ref--	Control	--Ref--	Control	--Ref--
Treatment 1 (=1 if the sale is under treatment 1)	0.0316* (0.0166)	Treatment 1 (=1 if the sale is under treatment 1)	0.0998 (0.149)	Treatment 1 (=1 if the sale is under treatment 1)	-0.651 (0.574)
Treatment 2 (=1 if the sale is under treatment 2)	-0.0985 (0.136)	Treatment 2 (=1 if the sale is under treatment 2)	0.486** (0.204)	Treatment 2 (=1 if the sale is under treatment 2)	-0.333 (0.854)
Treatment 3 (=1 if the sale is under treatment 3)	-0.489 (0.303)	Treatment 3 (=1 if the sale is under treatment 3)	0.371* (0.208)	Treatment 3 (=1 if the sale is under treatment 3)	0.212 (0.425)
Attributes		**Attributes**		**Attributes**	
Capacity (kg)	0.0349*** (0.00763)	Capacity- Volume of the fridge (L)	0.00184*** (0.000334)	Width (=1 if the size is 600 mm)	0.548** (0.251)
Type of embedding (=1 if free installation)	0.145*** (0.0381)	Capacity- Volume of the freezer (L)	0.000671 (0.000776)	Number of services	0.149** (0.0652)
Water consumption (L)	-2.82e-05*** (6.19e-06)	Price (€)	0.000316*** (7.40e-05)	Water consumption (L)	-0.00191*** (0.000233)
Price **(€)**	3.92e-05 (3.06e-05)	Treatment 1 * Price	-7.57e-05 (9.35e-05)	Price (€)	0.000350 (0.000521)
Treatment 1 * Price	-7.35e-05* (4.30e-05)	Treatment 2 * Price	-0.000245*** (8.15e-05)	Treatment 1 * Price	0.00109 (0.00105)
Treatment 2 * Price	3.23e-05 (4.30e-05)	Treatment 3 * Price	-0.000195** (9.10e-05)	Treatment 2 * Price	0.000286 (0.000883)
Treatment 3 * Price	2.14e-05 (4.65e-05)			Treatment 3 * Price	0.00141* (0.000823)
Socio-economic factors		**Socio-economic factors**		**Socio-economic factors**	
Income (€)	-5.16e-07 (3.46e-06)	Income (€)	1.11e-05 (1.46e-05)	Small city (=1 if the sale occurred in a small city)	0.0540 (0.128)
Income^2 (€)	0 (8.31e-11)	Income^2 (€)	-3.01e-10 (3.33e-10)	Big city (=1 if the sale occurred in a big city)	-0.0239 (0.0936)
Treatment 1 * Income	-1.09e-06 (1.82e-06)	Small city (=1 if the sale occurred in a small city)	-0.0197 (0.0269)	Income (€)	-5.75e-06 (6.05e-05)
Treatment 2 * Income	1.29e-06 (1.49e-06)	Big city (=1 if the sale occurred in a big city)	0.0294 (0.0181)	Income ^{2} (€)	1.69e-10 (1.33e-09)
Treatment 3 * Income	3.99e-06** (1.69e-06)	Age under 30 (=1 if the consumer is less than 30 years old)	0.0155 (0.0672)	Treatment 1 * Income	1.69e-06 (2.76e-05)
		Age 30 - 45 (=1 if the consumer is between 30 and 45 years old)	-0.0252* (0.0153)	Treatment 2 * Income	8.07e-06 (2.80e-05)
		Age over 60 (=1 if the consumer is more than 60 years old)	-0.0241 (0.0162)	Treatment 3 * Income	-4.47e-05* (2.43e-05)
				Age under 30 (=1 if the consumer is less than 30 years old)	-0.0102 (0.377)
				Age 30 - 45 (=1 if the consumer is between 30 and 45 years old)	-0.116 (0.113)
				Age over 60 (=1 if the consumer is more than 60 years old)	-0.173* (0.101)
Number of observations = 1,350 LR chi2(14) = 195.03 Prob > chi2 = 0.0000 Log likelihood = -200.57817 Pseudo R^2 = 0.3271		Number of observations = 827 LR chi2(15) = 257.88 Prob > chi2 = 0.0000 Log likelihood = -211.76056 Pseudo R^2 = 0.3785		Number of observations = 421 LR chi2(19) = 409.59 Prob > chi2 = 0.0000 Log likelihood = -81.001876 Pseudo R^2 = 0.7166	

2.6.4 Comparison between performance of models

The huge difference between the R^2 of washing machines and fridges on the one hand and that of dishwashers on the other is particularly interesting. A look at the literature reveals that the variables affecting willingness to pay for energy efficiency in washing machines, fridges and dishwashers are quite different. According to Galarraga et al. (2012) the most significant variables affecting willingness to pay for energy efficiency (and thus decision-making) in washing machines are those shown in Table 9. As can be seen in this Table, the variables in italics (spin speed, width, depth and colour) cannot be controlled in this study. Similarly, in the case of fridges Galarraga et al. (2011b) control colour and defrosting but we are unable to. For dishwashers the only variables controlled in Galarraga et al. (2011a) but not in our study are depth, drying efficiency and colour. In the end these uncontrolled variables could explain the differences in the R^2 of washing machines, fridges and dishwashers. These uncontrolled variables for washing machines and fridges might be expected to help explain our model better, but those for dishwashers are not so important for explaining it. In the end, these differences in R^2 show that we have captured the relevant variables for decision-making quite well for dishwashers, but may be missing some interesting attributes for decision-making in regard to washing machines and fridges.

Table 9: Comparison between the significant attribute variables in the literature and in this study

Washing machines		**Fridge**		**Dishwasher**	
Galarraga et al. (2012)	**This paper**	**Galarraga et al. (2012)**	**This paper**	**Galarraga et al. (2011)**	**This paper**
Energy efficiency level	Energy efficiency level	Energy efficiency level	Energy efficiency level	Energy efficiency level	Energy efficiency level
	Brand	Brand	Brand	Brand	Brand
Capacity (kg)	Capacity (kg)		Height	*Height*	
Type	Type		Type	Width	Width
Type of embedding	Type of embedding	Type of embedding	Type of embedding	*Depth*	
	Water consumption	Volume	Volume (fridge and freezer)	*Drying efficiency*	
Spinning					Type of embedding
Width		*Defrosting*			Water consumption
Depth		*Colour (e.g. colour steel)*		Number of services	Number of services
Colour (e.g. white)				*Colour (e.g. steel)*	
				Anti-fingerprint	

2.6.5 Limitations and caveats

One of the main benefits of running a field experiment is that it makes it possible to test in the real world, with real purchasers and real purchases, whether or not a new policy or instrument is effective. However, one of the main disadvantages is that many factors could be “uncontrollable” due to the design of the experiment, the human factor or factors related to retailers.

One of the main caveats of this study is that we were unable to control several factors due to the design of the experiment. Time effects are just an example: we only have observations from the period of the experiment, so we have no hint as to potential sales trends throughout the year. Average sales in certain months (e.g. Easter holidays) might be expected to be lower in inland towns but higher in coastal resorts. In addition, we have tested if there are any time effects during each treatment in the period of the experiment, and no effects were found for any of the appliances. Another relevant factor that is not controlled is potential mental fatigue among sales staff and retailers during the field experiment.

Other limitations stem from the impossibility of obtaining certain information related to purchasers. During the initial stages of the design phase we considered collecting substantial information from buyers such as income level, education, whether they were first time buyers, etc. However, the retailers and chambers of commerce strongly argued against it on the grounds that their average customer was usually reluctant to provide such information (sometimes because many customers belong to the same small community) and sales staff in small stores were very reluctant to collect it (mainly arguing lack of time and resources). Therefore, as a compromise we finally decided to only ask for post codes and to obtain aggregate information from the statistical office. In addition to the aforementioned limitations, consumers’ preferences are not captured in this field experiment due to fact that we could not conduct a post-sale survey. A hypothetical post-sale survey could have asked about brand-loyalty, learned whether customers were first-time buyers or even asked if they had correctly understood the lifetime energy savings information.

We also assume some caveats such as the fact that we do not really know whether purchasers actually received the information related to an appliance in one treatment and purchased the product in another treatment. Another “uncontrolled” fact is that we could not ensure that sales staff always provided the lifetime energy savings information during Treatment 2 and Treatment 3.

Other caveats are related to the internal management of the retailers. For instance, some retailers have few appliances on display due to a lack of space.

2.7 Conclusions and policy recommendations

Increasing the adoption of energy-efficient technologies is one of the major challenges in the coming years if EU energy efficiency targets are to be met. Providing consumers with monetary information on energy savings from energy efficiency has been proposed in order to increase the purchase of energy-efficient appliances. However, some studies have shown discrepancies as to the effectiveness of this type of information.

This paper seeks to use behavioural economics to analyse the effectiveness of providing monetary information to consumers so as to promote the purchase of energy-efficient appliances in Spain. To that end a field experiment was carried out with 26 small retailers in Spain for three different appliances: washing machines, fridges and dishwashers. Lifetime energy savings information in the form of a monetary label was provided in addition to the existing energy efficiency label.

Three different treatments were tested. The first consisted of providing lifetime energy savings information via a monetary label. During this treatment, consumers had access to lifetime energy savings information only through the monetary label and sales staff were required not to give such information. The second treatment consisted of training sales staff to provide monetary information but not providing a monetary label, i.e. consumers received lifetime energy savings information only from sales staff. Finally, the two treatments were combined so that there was a monetary label and information was also given by sales staff.

The decision-making process for each appliance can differ. Different variables may be more important for different appliances (washing machines, fridges and dishwashers).

Our findings suggest that monetary labels presenting lifetime energy savings information may be effective in promoting the purchase of high energy-efficiency (A^{+++}) washing machines. However, when the label is combined with information from sales staff it ceases to be effective. These results seem counterintuitive. Possible explanations may include “mental fatigue” on the part of sales staff in the last few months of the field experiment. Sales staff may also have had little incentive to encourage people to purchase A^{+++} washing machines, as most of the machines available at most retailers were already A^{+++}. Different results were obtained for fridges: both Treatment 2 (information on energy savings given by sales staff) and Treatment 3 (information on energy savings given by a monetary label and by sales staff) were found to increase the probability of buying a high energy-efficiency (A^{+++}) fridge compared to the control group. Moreover, Treatment 2 (intervention of sales staff) seems to have been more effective than

Treatment 3 (combination of intervention of sales staff and monetary label). This may also reflect the “mental fatigue” mentioned above. None of the treatments seems to have been effective in promoting the purchase of energy-efficient dishwashers. This is also a rather surprising result. InitiItxaally, consumers might be expected to behave and make decisions similarly when purchasing washing machines and dishwashers, but that is not what our field experiment showed. One possible explanation is that washing machines can be considered as a primary appliance in households while dishwashers are not. In fact, during the field experiment three times as many washing machines were sold (1350) as dishwashers (421). Moreover, people seem to care more about the energy efficiency level of fridges because they are connected 24/7.

In all the appliances studied, the technical attributes for product size were found to be significant and increase the probability of buying a high energy-efficiency appliance. Heterogeneous effects were found in the interacted variables (e.g. treatment and price) depending on the product category. This may indicate that the effectiveness of the energy savings information combined with technical attributes could impact investment decisions differently depending on the product category.

As regards socio-economic factors, heterogeneous impacts were observed for age. This may indicate that decisions by consumers could change depending on their ages and on the appliance in question. One possible explanation may lie in socio-demographic factors in Spain: people aged between 30 and 45 may have families and other responsibilities which leave them with less disposable income to invest in energy efficiency. Income effects also differ for each product category, which could indicate that income is a determinant variable in decision-making for washing machines and dishwashers.

Our findings suggest that providing lifetime energy savings information can be useful in promoting the purchase of high energy-efficient (A^{+++}) appliances in Spain, especially for washing machines and fridges. The results of this study indicate that monetary information could be useful for particular appliances but not for all household appliances. To promote energy-efficient purchases, different monetary labels could be proposed for each appliance type, taking into account the peculiarities of each product category, consumer preferences and habits towards each one, the socio-economic profile of consumers, the country of implementation and the way in which monetary information is provided.

However, further research is needed to further understanding of the effects of all these factors in terms of successfully nudging consumers towards energy-efficient appliances and especially the preferences of households regarding different types of appliance, which seem to be key in understanding consumer decision-making for the purchase of appliances. In particular, more research is needed to analyse the impact of income on the purchase of household appliances and to understand how important consumers consider each household appliance to be. Moreover, for future experimental studies it would be interesting to control for possible time effects in the experiment, potential staff fatigue and psychological effects of providing one type of information or other (lifetime energy savings vs. lifetime energy cost).

3 Effectiveness of monetary information in promoting the purchase of energy-efficient appliances: evidence from a field experiment at a major retailer in Spain

3.1 Introduction

Energy efficiency (EE) is crucial for achieving energy savings, especially in household energy consumption (Labandeira et al., 2020; Solà et al., 2020). EE, defined as improvements in the efficiency with which energy is used to provide a service, has several private and social benefits (cost reduction, emissions reductions... etc.), but these are not always enough to successfully nudge consumers towards energy-efficient choices. Even when EE may prove financially profitable for consumers, they may not always invest as much as may seem rational (Gerarden et al., 2017; Linares and Labandeira, 2010). This effect is known as the *energy efficiency gap* or the *energy efficiency paradox.* It refers to situations in which apparently beneficial investments are not made, and/or apparently non-beneficial ones are (Jaffe and Stavins, 1994b). There are several failures that could promote the EE gap; they can be grouped under the headings of *market failures*, *behavioural failures* and *other personal factors*. A recent review of the literature on the *EE gap* can be found in Solà et al. (2020).

In this paper, we focus on informational failures and instruments for tackling them. Such failures involve situations in which a lack of information or misunderstanding of information can negatively affect financial decisions. These include *asymmetric* and *imperfect* information (Allcott and Sweeney, 2016; Davis and Metcalf, 2016; Yeomans and Herberich, 2014), *hidden* and *transaction costs* (Ramos et al., 2015; Sorrell et al., 2004), *myopia* (Busse et al., 2013; Cohen et al., 2017; Gerarden et al., 2017) and *uncertainty* (Greene, 2011; Ramos et al., 2015; Tversky and Kahneman, 1981).

The most common policy instruments for addressing informational failures are energy labels (Galarraga et al., 2011b), smart meters and information feedback tools (Carroll et al., 2014; Hoffmann and Thommes, 2020) and energy audits (Anderson and Newell, 2004; Krutwig and Tanțău, 2018). Energy labels in particular are the single most widely used instrument for addressing information failures and reducing the EE gap (Solà et al., 2020). The information provided on labels differs depending on the product category (e.g. household appliances, cars, dwellings). In the case of household appliances, the EE label usually indicates EE level in physical units (energy consumption in kWh/year) and other technical attributes (size/capacity, noise level, etc.).

Labels are used extensively (also to identify appliances eligible for rebate programmes), so their effectiveness is important to successfully promote the adoption of energy-efficient appliances with a view to at least meeting the 32.5% target for energy savings by 2030 (Energy Efficiency

Directive (2018/2002)). Consumers often misunderstand the energy consumption (in kWh/year) displayed on the label (Waechter et al., 2015a), so recent studies have proposed using monetary information (Allcott and Taubinsky, 2015; Carroll et al., 2016b; Deutsch, 2010; Kallbekken et al., 2013; Skourtos et al., 2021; Stadelmann and Schubert, 2018). Despite the growing body of research devoted to testing the effectiveness of using energy consumption information in monetary terms to successfully nudge consumers towards energy-efficient products, there is no clear consensus as yet.

Some studies show that providing consumers with monetary information helps to promote the purchase of energy-efficient products while tackling the EE gap. For instance, Kallbekken et al. (2013) run a field experiment in Norway to test the effectiveness of providing monetary information through the use of supplementary labels and training for sales staff. They consider two appliances and find that such information is effective for tumble-driers but not for fridge-freezers. Other interesting results on the effectiveness of labels for tumble-driers and vacuum cleaners can be found in Stadelmann and Schubert (2018). These authors run a field experiment to compare effectiveness in different scenarios (no label, EU Energy label and monetary energy label based on annual energy consumption) in Switzerland. They find that sales of efficient appliances increase with the presence of any of the labels. In the case of washing-machines, Deutsch (2010) shows in an online field experiment that when monetary information is displayed there is a reduction in average energy consumption based on the label of 0.8%. In line with these results, Blasch et al. (2022) show that energy and investment literacy are positively correlated with the probability of investing on EE. Solà et al. (2021a) show through a field experiment conducted at small retailers in Spain that providing lifetime energy saving information is effective in promoting the purchase of highly efficient washing-machines and fridges, but they find no effect for dishwashers.

Other studies find that this type of information has no significant effect in promoting energy-efficient purchases. This is the case of the study by Carroll et al. (2016b) in Ireland for tumble-driers. Their findings show that such information has no statistically significant effect. Nor is any effect detected in the field experiment by Stadelmann and Schubert (2018) for freezers mentioned above. The authors argue that this could be due to a lack of awareness of this type of labels. A choice experiment run with fridges by Skourtous et al.(2021) find that including annual operating cost is no effective on consumers' choices. These authors propose to use monetary information on saving terms to promote the purchase of highly efficient appliances.

In short, it is not entirely clear whether displaying monetary information is effective in enhancing the purchase of high-efficiency appliances and significant differences are found depending on the product category and country analysed. In an attempt to shed more light on these questions, this paper analyses whether providing information on the lifetime energy cost of household appliances sold in Spain could successfully nudge consumers towards purchasing the most energy-efficient options.

This is done through a field experiment undertaken with the support of a well-known major Spanish retailer: El Corte Inglés[21]. Information on energy costs over the lifetime of a product (appliance) is displayed in Euros (referred to from now on as *monetary information*). Four of the most widely used household appliances[22] were selected (washing-machines, fridges, dishwashers and tumble-driers) to study whether monetary information has different impacts on consumer decisions for different appliances. The information is displayed in two formats: 1) trained sales staff provide the information; and 2) trained sales staff provide the information and at the same time a supplementary label with monetary information is included on each appliance. The appliances chosen and the way in which information is provided are two of the main improvements over previous studies (Carroll et al., 2016b; Kallbekken et al., 2013; Solà et al., 2021a). This enables us to better understand the decision-making process for each appliance. Moreover, the experiment is run at a major retailer, so we were able to ensure that treatments were run similarly and with the same criteria.

A total of 29 El Corte Inglés stores in 9 regions of Spain took part in the experiment. In two of these regions (Aragón[23] and Madrid[24]), a rebate programme called RENOVE had been run a few months prior to the start date of the experiment. This rebate programme consisted of subsidising the replacement of old appliances by new, more energy-efficient models. RENOVE programmes are run by regional governments and differ from one region to another. The existence of the earlier RENOVE programmes in some regions enabled us to test whether they might bias (or have an effect on) the experiment itself, i.e. whether there might be a long-run effect of the rebate programme even when it was no longer in place. We refer to this as a *memory effect*.

[21] See the El Corte Inglés website: https://www.elcorteingles.es/

[22] https://www.eea.europa.eu/data-and-maps/daviz/energy-consumption-for-electric-appliances-2#tab-chart_1

[23] The subsidy was €150 for A+++ washing-machines, €150 for A+++ fridges and €145 for A+++ dishwashers. The total funding endowment of this RENOVE was €1,300,000.

[24] They gave subsidies of up to €70 for A+++ labelled washing-machines, up to €150 for fridges and up to €110 for dishwashers. The total funding endowment of this RENOVE was €2,780,000.

The rest of the paper is structured as follows: Section 3.2 presents the design of the field experiment. Section 3.3 shows the data and how they were collected. Section 3.4 explains the methodology used. Section 3.5 presents and discusses the results of the study. Finally, Section 6 concludes and provides some policy recommendations.

3.2 Design of the field experiment

The 29 stores that participated in the experiment were selected based on geographical distribution across nine regions of Spain (for further details see Section 3.3).

The stores were classified into two groups: (i) treatment group (10 stores); and (ii) control group (19 stores). The stores in the treatment group were responsible for implementing the treatments while those in the control group maintained a business-as-usual scenario. The choice of which stores were assigned to the treatment and control groups was made by El Corte Inglés based on the characteristics of the stores and their distance from the central offices in Madrid. As both treatments require plenty of administrative steps, the retailer decided to assign the stores near the central offices to the treatment group. These administrative issues included the distribution of complementary labels, the complete list of appliances in stock, among many others. Besides, El Corte Inglés manager visited regularly the treated stores in order to ensure that the exercise was running smoothly.

The experiment ran from 15th August to 24th December 2018. Treatment 1 consisted of providing consumers with monetary information via sales staff and Treatment 2 of providing monetary information via the sales staff and via a supplementary label (see Table 10). The label used in this treatment shows lifetime energy cost (*LEC*) information in Euros for all the products under study (washing-machines, fridges, dishwashers and tumble-driers).

Table 10: timeline of the experiment

Experiment design	Source of monetary information	Period
Control	Business as usual	15th August 2018 -24th December 2018
Treatment 1	Sales staff	15th August 2018 -30th October 2018
Treatment 2	Supplementary label + sales staff	1st November 2018- 24th December 2018

3.2.1 Training of sales staff

Two weeks before the start of the experiment, sales staff received a training session on EE-related topics (see Appendix A4 in *Annex-Chapter 3*). This consisted of a researcher going to the central offices of the company and providing a training session for the heads of the appliance departments at all the stores in the treatments.

The training session explained the main concepts of the experiment and the timing. It also explained how monetary information had been estimated based on the annual energy consumption given on the EE label. Tables with the estimated monetary information were distributed.

Once the training session was over, sales staff were provided with full information in a printed book and a video with all the explanations needed, in an attempt to minimise potential misunderstandings and deviations. It was thus possible to ensure that all sales staff received the same information. In addition, the central offices of El Corte Inglés made regular telephone calls to each store to ensure that all the tasks (e.g. that all appliances should have a supplementary label) were carried out correctly and consistently.

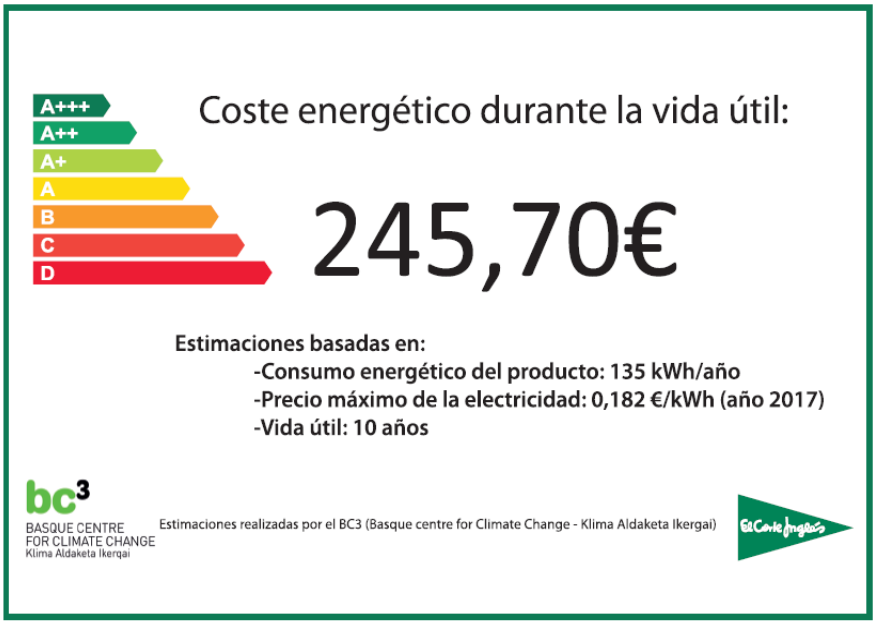

Figure 4: Supplementary label used in the field experiment (Translation: Energy cost over the useful lifetime of the product: €245.70. Estimations based on: energy consumption 135 kWh/year; maximum energy price €0.182/kWh (2017); lifetime: 10 years).

3.2.2 Description of the treatments

In Treatment 1 monetary information was provided by trained sales staff. It started in mid-August and ended on 30th October. During this period the principal role of the trained sales staff was to give monetary information verbally to all consumers interested in any of the appliances under study. In order to ensure that sales staff provided the correct monetary information, in the training session several notebooks were delivered to each centre. In this notebook, there was a section devoted to display tables with the annual energy consumption and the corresponding monetary information for each appliance.

Treatment 2 started on 1st November and ended on 24th December. In this period consumers received monetary information through two different channels: sales staff and a supplementary label (see Figure 4). Before this second treatment started, we received information about the appliances in stock at the stores involved in the treatment (product categories and models). With this data, we prepared a database including technical attributes such as the energy consumption of the products and models sold or available in stock, so as to produce the corresponding label for each appliance. In complementary labels, the EE level of the product was not specified, as these labels were placed next to the official (European) EE label, that must be visible at the point of sale for household appliances[25].

A total of 206 different labels were printed during this treatment (50 for washing-machines; 86 for fridges; 36 for dishwashers; 34 for tumble-driers).

Treatment 2 was supposed to start in mid-October so that each treatment would last two months, but there was a delay of 15 days due to problems in actually producing the supplementary labels.

3.2.3 Estimation of lifetime energy cost (LEC)

The monetary information provided during the experiment required the LEC to be estimated for each appliance. We used the following equation:

$$LEC_i = EC_i * ep_{2017} * L,$$

where EC_i is the annual energy consumption of each product i; ep_{2017} is the maximum energy price registered in 2017[26] and *L* is the lifetime of the appliance in years. Thus, we estimated the *LEC* for each appliance. For the lifetime of the products, suggestions made at our meetings with small retailers and experts led us to use a figure of 10 years for all appliances, which seems also to be the average in Spain (Organización de Consumidores y Usuarios, 2020).

The colour scale derived from the European EE label was placed on the left side of the supplementary label to link the information provided with the EU EE label (see Picture 1). As pointed out by de Ayala et al. (2020), this colour scale is familiar and understandable for

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[25] https://europa.eu/youreurope/business/product-requirements/labels-markings/energy-labels/index_en.htm

[26] Red Eléctrica Española publishes all the data for PVPC (*Precio Voluntario para el Pequeño Consumidor* – Voluntary Price for Small-scale Consumers) on the Spanish market on this website: https://www.esios.ree.es/es/pvpc. We chose the highest energy price recorded because it was closer to the price that consumers were actually paying.

households. The logos of the research centre leading the experiment and the logo of the store were placed at the bottom of the label. This was considered a simple way to build trust by conveying the message that independent specialists had made the calculations. Consumers were not informed that the supplementary labels were part of a field experiment or research project, so as not to bias the purchasing decision-making process.

3.3 Data collected and descriptive statistics

The 29 stores involved were distributed across the different regions of Spain as follows: Andalusia (2), Aragón (1), Madrid (12), Catalonia (4), Basque Country (1), Valencia (4), Galicia (2), Balearic Islands (1) and Murcia (2).

El Corte Inglés provided us with the following information: (1) store where the appliance was sold; (2) date of sale; (3) type of appliance sold; and (4) model of the product. We then merged the data with our technical attribute database. In the case of washing-machines, we collected information on capacity (in kg), type of embedding and water consumption (in L) for each model. For fridges, we collected information on fridge and freezer volumes (in L), type of embedding and type of fridge. In the case of dishwashers, information on width (450 mm or 600 mm), number of services, type of embedding and water consumption (in L) was collected. Finally, for tumble-driers we collected information on size (kg), type of embedding and spin speed (descriptive statistics shown in Table A5 in *Annex-Chapter 3*). Table 11 shows the sources for each type of data collected.

Table 11: Variables and sources

Data collected	Source
Date and place of sale	El Corte Inglés
Type, brand and model of appliance sold	El Corte Inglés
EE level, energy consumption and technical attributes of the appliance sold	Database on technical attributes
Catalogue price of the appliance sold	El Corte Inglés website
Per capita income	INE database

The number of sales recorded during the field experiment at El Corte Inglés was 67,345 units. The breakdown per product was as follows: 25,554 washing-machines, 17,911 fridges, 16,903 dishwashers and 6,977 tumble-driers. In percentage terms (Table 12), 38.4% of the units sold were washing-machines, 26.9% were fridges, 24.2% were dishwashers and 10.5% were tumble-driers. All this data is based on the real sales during the period of the experiment.

To follow up how sales behaved in the treatment and control groups, the shares of A^{+++}, A^{++} and A^{+} sold under Treatment 1, Treatment 2 and the control group for each appliance were calculated.

As shown in Table 12, for washing-machines A^{+++} products accounted for above 98% of sales in both the treatment and control groups. For fridges A^{+++} products accounted over 40%. For dishwashers and tumble-driers the figures were lower. For dishwashers A^{+++} products amounted to less than 20% of the sales and for tumble-driers there were differences between the groups. In Treatment 2 the share of A^{+++} tumble-driers sold was over 30%, while in Treatment 1 and the control group it was slightly higher than 20%. Figure A3 (in *Annex-Chapter 3*) shows the distribution of energy consumption by product category and EE level.

For reasons of confidentiality and business strategy, El Corte Inglés did not provide the final selling price for every appliance sold. We decided to obtain the official catalogue prices shown on their website for each product. These official catalogue prices should be a good proxy of the real price, but we were unable to account for price variations due to business strategies (if any). In the case of washing-machines and fridges, the most expensive products were sold in Treatment 2, for dishwashers in the control group and for tumble-driers in Treatment 1 (average catalogue prices are shown in Table A6 in *Annex-Chapter 3*).

Due to confidentiality issues, we did not obtain information on the income of each purchaser. To analyse the effect of income on consumers' purchase decisions in regard to more energy-efficient products, we use the average income in the area where each store is located as a proxy.

Table 12: % of appliances sold by EE level and period

		A+++	A++	A+	A	B	C	D
Washing-machines (38.41%)	Control	98.63%	1.25%	0.13%	.	.	.	.
	Treatment 1	97.75%	1.90%	0.35%	.	.	.	.
	Treatment 2	98.53%	1.42%	0.05%	.	.	.	.
Fridges (26.92%)	Control	41.78%	51.80%	6.41%	.	.	.	0.01%
	Treatment 1	39.13%	52.94%	7.89%	.	.	.	0.05%
	Treatment 2	42.10%	51.91%	5.99%	.	.	.	.
Dishwashers (24.19%)	Control	18.49%	69.61%	11.89%	0.01%	.	.	.
	Treatment 1	20.04%	66.83%	13.13%	.	.	.	.
	Treatment 2	17.49%	69.24%	13.28%	.	.	.	.
Tumble-driers (10.48%)	Control	20.59%	55.89%	6.14%	.	13.76%	3.63%	.
	Treatment 1	22.70%	58.03%	6.64%	.	10.39%	2.25%	.
	Treatment 2	31.90%	57.74%	3.61%	.	5.82%	0.93%	.

3.4 Model specification

We use a multinomial logistic approach to measure the effectiveness of providing monetary information to consumers through different channels at the point of sale. This enables us to estimate the effect of the treatments on the probability of buying an energy-efficient appliance for each EE level. This approach means that we can control for external factors affecting both the treatment and control groups.

We present the following identifying equation for the multinomial logit estimation[27]:

$$\Pr(y|X) = \beta_0 + \beta_1 Treat1 + \beta_2 Treat2 + \sum_{i=1}^{m} \beta_i \, Attributes_i + \beta_{m+1} Income + \beta_{m+2} Renove + \beta_{m+3} Price + \varepsilon \qquad (1)$$

This model can be expressed as $P(y|\,X)$, where y is the EE level and X contains explanatory variables where $Treat1$ is 1 if the sale takes place under Treatment 1, and thus β_1 captures whether Treatment 1 (monetary information provided by sales staff) increases or decreases the probability of buying highly energy-efficient appliances. Analogously, $Treat2$ is 1 if the sale takes place under Treatment 2 (monetary information provided by sales staff and a supplementary

[27] The multinomial logit model can be used when all the regressors are case-specific (Cameron et al., 2005), so the multinomial model specifies that $p_{ij} = \frac{\exp(x_i'\beta_j)}{\sum_{l=1}^{m}(x_i'\beta_l)}, j = 1, \dots m,$ where x_i are case-specific regressors. Clearly, this model ensures that $0 < p_{ij} < 1$. To ensure the correct model identification, β_j is set to zero for one of the categories, called the reference category or base, and the rest of the coefficients are interpreted with respect to that category.

label), so β_2 captures whether Treatment 2 increases or decreases the probability of buying high-efficiency appliances. $Attributes$ capture those variables that describe specific characteristics of each appliance, e.g. capacity (in kg) and water consumption (in L) for washing-machines; height (in mm) for fridges; size (450mm or 600mm), number of services and water consumption (in L) for dishwashers; and type alone for tumble-driers.

As can be seen in Equation (1), we also include $Income$ (average per capita income in the area where the product is sold), $Renove$ (with a value of 1 if the place where the product was sold had run a RENOVE rebate scheme before the experiment started) and $Price$ (showing the official catalogue price of the product). We also introduce the variable $Renove$ to test if the prior presence of the RENOVE affects somehow the sales and the results of our experiment. Finally, note that $Price$ refers to the catalogue price of the product as stated earlier and may differ from the actual final sale price of the appliance.

We first run a model with treatment variables. Then we include the rest of the variables one by one and choose the model with the highest level of significance. Thus, for each type of appliance we estimate different models that reflect the probability of buying a highly energy-efficient appliance depending on the treatment, technical attributes, income, RENOVE and price. Specification (2) refers to the model for washing-machines, (3) for fridges, (4) for dishwashers and (5) for tumble-driers.

$$\Pr(y|x) = \beta_0 + \beta_1 Treat1 + \beta_2 Treat2 + \beta_3 Capacity + \beta_4 WaterConsumption + \beta_5 Income + \beta_6 Renove + \beta_7 Price + \varepsilon \quad (2),$$

$$\Pr(y|x) = \beta_0 + \beta_1 Treat1 + \beta_2 Treat2 + \beta_3 Height + \beta_4 VolumeFreezer + \beta_5 Income + \beta_6 Renove + \beta_7 Price + \varepsilon \quad (3),$$

$$\Pr(y|x) = \beta_0 + \beta_1 Treat1 + \beta_2 Treat2 + \beta_3 Width + \beta_4 NumberServices + \beta_5 WaterConsumption + \beta_6 Income + \beta_7 Renove + \beta_8 Price + \varepsilon \quad (4),$$

$$\Pr(y|x) = \beta_0 + \beta_1 Treat1 + \beta_2 Treat2 + \beta_3 TypeofTumbleDrier + \beta_4 Income + \beta_5 Renove + \beta_6 Price + \varepsilon \quad (5).$$

3.5 Results and discussion

3.5.1 Results of the field experiment

In this section we set out and discuss the results of the multinomial logistic analysis for each of the four appliances considered. The probabilistic models (2), (3), (4) and (5) were estimated using STATA version 16. The marginal effects for the treatments and the explanatory variables are shown in Table 13 (for washing-machines and fridges), Table 14 (for dishwashers and tumble-driers), while Table 15 shows a summary of the effectiveness of each treatment by product and EE level. We discuss these results and contextualise them in the relevant literature.

(i) Treatment effect

The effectiveness of Treatment 1 (information provided by sales staff) and Treatment 2 (information provided by sales staff plus a supplementary label) differs from one product category and EE level to another.

In particular, Treatment 1 is effective and increases the probability of buying A^{++} washing-machines by 0.8% but it decreases the probability of buying A^{+++} washing-machines compared to the control group. It does not therefore incentivise the purchase of highly efficient appliances. The main reason is that, in the case of washing-machines, A^{+++} products already account for a very high share of sales and the scope for improvement is really small. In fact, more than 98% of the units sold in the control stores were A^{+++}.

In the case of fridges and dishwashers, Treatment 1 is effective in increasing the probability of purchasing A^{++} (by 5.5% for fridges and 5.15% for dishwashers) but the probability of buying an A^{+++} product decreases (by 6.36% for fridges and 2.5% for dishwashers). This suggests that sales staff were unable to nudge customers towards purchasing of highly efficient fridges and dishwashers. The substantial differences in price between A^{+++} and A^{++} fridges and dishwashers could also explain this effect. A^{+++} fridges cost 27.68% more than A^{++} and A^{+++} dishwashers cost 34.89% more than A^{++}. Treatment 1 is not statistically significant in terms of increasing sales of highly efficient tumble-driers, as can be seen in Table 14.

The effectiveness of Treatment 2 also differs depending on the appliance and the EE level. This treatment is effective in nudging purchaser towards A^{++} with increases of 1.2% for washing-machines and 2.9% for dishwashers, but the probability of buying an A^{+++} unit decreases by 1.2% for washing-machines and 3.2% for dishwashers. The latter result is again unexpected: it may be explained by the same reason indicated above. As shown in Table 14, providing monetary information via sales staff and a supplementary label increases the probability of buying A^{+++} tumble-driers by 4.01% compared to no intervention. This is an expected result.

Overall, Treatments 1 and 2 both appear to be statistically significant and therefore effective in promoting the purchase of A^{++} appliances (see Table 15). However, this is not the case for A^{+++} appliances, in particular for washing-machines, fridges and dishwashers. As noted, these are unexpected results. On potential explanations might be that sales staff fail to offer sufficient information to successfully nudge consumers towards A^{+++} purchases for reasons beyond our understanding. Other explanations might be related to other attributes of appliances that we are unable to control for in the experiment (e.g. simplicity of use). In addition, the treatments seemed to work well for some products but not for others.

In any case, this is consistent with the existing literature on the topic, which clearly shows that monetary information has heterogeneous effects depending on the type of appliance and/or country. Some studies find no evidence for the effectiveness of providing monetary information. Carroll et al. (2016b) show no evidence for the effectiveness of 5 year energy cost information for tumble-driers. However, Kallbekken et al. (2013) report that monetary information is effective for tumble-driers but not for freezers, and similar results are obtained by Stadelmann and Schubert (2018). Our results for tumble-driers are in line with those of Kallbekken et al. (2013).

(ii) Attributes

It is clear that attributes are important factors for the decision-making process. In the case of washing-machines, two attributes were included in the analysis: capacity and water consumption. Both are statistically significant. In the case of capacity (in kg) we find that the higher the capacity is, the greater the probability of buying A^{+++} washing-machines is. Water consumption increases the probability of buying A^{++} washing-machines but decreases that of buying A^{+++} appliances. These results are expected: in general, the higher capacity is, the higher the EE level of products is, and a higher EE level means lower water consumption.

In the case of fridges, two attributes are considered: height and freezer capacity. The taller the fridge is, the greater the probability of buying an A^{+++} model is, but the lower the probability of buying an A^{++} model is. This evidence is somewhat intuitive: bigger fridges usually have high EE levels. In the case of the freezer volume, the greater the volume is, the greater the probability of buying an A^{++} fridge is, and the lower the probability of buying an A^{+++}. Even if the impact of the freezer volume is small, it could be somewhat intuitive, as higher freezer volumes mean greater energy consumption, and this could affect the EE level of the product[28].

For dishwashers we included three attributes: width, number of services and water consumption. Table 14 shows that the number of services is effective in promoting the purchase of highly energy-efficient dishwashers. The more services can be obtained, the greater the probability of buying an A^{+++} dishwashers is, with increases of up to 9.5% compared to the control group (no intervention). This result is intuitive in the sense that bigger products usually have higher efficiency levels. But this same variable decreases the probability of buying A^{++} dishwashers. In the case of water consumption, greater water consumption means a lower probability of buying an A^{+++} dishwasher.

In the case of tumble-driers, we only included type as an explanatory variable. Our database contains three different types of tumble-drier: heat-pump, condensation and evacuation. As can be seen in Table 14, heat-pump tumble-driers are taken as the benchmark. Choosing a condensation tumble-drier decreases the probability of buying an A^{++} appliance. A similar effect is found for evacuation tumble-driers. In fact, a decrease in the probability of buying an A^{++} appliance can be observed.

As can be seen, attributes are relevant factors in decision-making processes. In particular, the higher the capacity and the greater the water consumption, the more likely it is that the consumer will decide to invest in highly energy-efficient appliances (A^{+++} appliances). This is in line with previous results in the literature, as the great majority of studies show that consumers care about the technical characteristics of products (de Ayala et al., 2020; Galarraga et al., 2011a, 2011b).

(iii) Price effect

Price has heterogeneous effects on consumer decision-making. In this study we find two different effects: for washing-machines, the higher the price, the higher the probability of buying A^{++} washing-machines and the lower the probability of buying A^{+++} washing-machines is. The contrary effect is found for fridges, dishwashers and tumble-driers, i.e. the higher the price, the higher the probability of buying A^{+++} products and lower the probability of buying A^{++} products.

The effect found for fridges, dishwashers and tumble-driers can easily be understood by looking at the average selling prices for each product (see Table A6 in *Annex-Chapter 3*). In fact, the

[28] The EE level of the product is determined by the *EE index,* which considers several attributes of the product (energy consumption, volume, etc).

average selling price for A^{++} fridges is €847.63 while the average catalogue price of A^{+++} fridges is €1082.27. Similar differences can be seen for dishwashers (an average catalogue price of €522.75 for A^{++} and €745.65 for A^{+++}) and tumble-driers (€773.89 for A^{++} and €1038.03 for A^{+++}). In the case of washing-machines, this effect can be explained by the fact that the difference in LEC between A+++ and A++ washing-machines does not offset the difference in price between them (the price for A^{+++} is €78.36 higher than for A^{++}). In fact, the difference in LEC between A^{+++} and A^{++} washing-machines is €63.59, so the difference in price means that it is not worth investing in high-efficiency washing-machines.

Overall, our results show that the price of products is a major factor to be considered in purchasing decisions, as many other papers have shown earlier. The literature also shows a positive willingness to pay for highly efficient products (de Ayala et al., 2020; Galarraga et al., 2011a, 2011b) and our results corroborate this.

(iv) Income effect

As is shown in Tables 13 and 14, the "income" variable is not statistically significant for washing-machines and dishwashers, but is significant for fridges and tumble-driers. It is important to note that this variable does not reflect the real income of consumers but merely the average income in the area where the product was sold. For fridges, results show that in higher-income locations the probability of buying an A^{++} fridge is greater, but that of buying an A^{+++} fridge is lower. By contrast, for tumble-driers the probability of buying a C labelled appliance increases in those areas where income is higher.

Table 13: Results of the multinomial logit model for washing-machines and fridges

Washing-machines			Fridge		
Energy efficiency level	Marginal effects	z	**Energy efficiency level**	Marginal effects	z
Treatment effect			***Treatment effects***		
Control	-- Ref --		**Control**	-- Ref --	
Treatment 1 (=1 if the sale is under treatment 1)			**Treatment 1 (=1 if the sale is under treatment 1)**		
A+	0.0003556 (0.0011761)	0.30	A+	0.0079952 (0.0056958)	1.40
A++	0.0083867** (0.004151)	2.02	A++	0.0556437*** (0.0180148)	3.09
A+++	-0.0087422** (0.0042299)	-2.07	A+++	-0.0636389*** (0.0173607)	-3.67
Treatment 2 (=1 if the sale is under treatment 2)			**Treatment 2 (=1 if the sale is under treatment 2)**		
A+	-0.0003483 (0.000838)	-0.42	A+	-0.0003099 (0.0065551)	-0.05
A++	0.0127624** (0.0052454)	2.43	A++	-0.0146885 (0.0195088)	-0.75
A+++	-0.0124141** (0.0052672)	-2.36	A+++	0.0149984 (0.0187263)	0.80
Attributes			***Attributes***		
Capacity (kg)			**Height (mm)**		
A+	-0.0018062*** (0.000374)	-4.83	A+	-0.0005734*** (0.0000393)	- 14.59
A++	-0.0273314*** (0.0013977)	- 19.55	A++	-0.0001075 (0.0000676)	-1.59
A+++	0.0291375*** (0.0014023)	20.78	A+++	0.0006809*** (0.0000577)	11.80
			Capacity- Freezer volume (L)		
			A+	-0.0022889*** (0.0001174)	- 19.49
			A++	0.0069364*** (0.0004175)	16.61
			A+++	-0.0046476*** (0.000411)	- 11.31
Water consumption (L)					
A+	-9.12e-07*** (2.56e-07)	-3.56			
A++	0.0000195*** (1.70e-06)	11.46			
A+++	-0.000186*** (1.71e-06)	- 10.90			
Income (in the area where the store is located)			***Income (in the area where the store is located)***		
A+	1.05e-08 (2.49e-08)	0.42	A+	-2.16e-07 (2.02e-07)	-1.07
A++	1.12e-07 (9.94e-08)	1.13	A++	1.28e-06** (6.36e-07)	2.02
A+++	-1.22e-07 (1.02e-07)	-1.20	A+++	-1.07e-06* (6.16e-07)	-1.73
RENOVE (=1 if the sale took place at a store where a RENOVE had been run prior to the experiment)			***RENOVE (=1 if the sale took place at a store where a RENOVE had been run prior to the experiment)***		
A+	-0.0006617 (0.0009096)	-0.73	A+	-0.0009739 (0.0052676)	-0.18
A++	-0.0074971*** (0.0029122)	-2.57	A++	-0.0441832*** (0.0157002)	-2.81
A+++	0.0081587*** (0.002993)	2.73	A+++	0.0451571*** (0.0150462)	3.00
Price (€)			***Price (€)***		
A+	1.24e-06 (1.64e-06)	0.75	A+	0.0000874*** (5.72e-06)	15.28
A++	0.0000483*** (3.54e-06)	13.64	A++	-0.0008021*** (0.0000214)	- 37.56
A+++	-0.0000495*** (3.75e-06)	- 13.20	A+++	0.0007146*** (0.0000196)	36.53
Number of obs = 24,311 LR chi2(14) = 1634.63 Prob > chi2 = 0.0000 Log likelihood = -1162.5471 Pseudo R2 = 0.4128			Number of obs = 11,097 LR chi2(14) = 4451.33 Prob > chi2 = 0.0000 Log likelihood = -6674.4406 Pseudo R2 = 0.2501		
Standard errors are shown in parentheses					
***, ** and * indicate significance at the 1%, 5% and 10% levels.					

Table 14: Results of the multinomial logit model for dishwashers and tumble-driers

Dishwashers			***Tumble-driers***		
Energy efficiency level	**Marginal effects**	**z**	**Energy efficiency level**	**Marginal effects**	**z**
Treatment effect			***Treatment effects***		
Control	--Ref--		**Control**	--Ref--	
Treatment 1 (=1 if the sale is under treatment 1)			**Treatment 1 (=1 if the sale is under treatment 1)**		
A+	-0.026459*** (0.0088507)	-2.99	C	0.0057116* (0.0032344)	1.77
A++	0.0515029*** (0.0163497)	3.15	B	0.0094579 (0.0094838)	1.00
A+++	-0.0250439* (0.0139055)	-1.80	A+	0.024586 (0.0149476)	1.64
			A++	-0.0109264 (0.0266957)	-0.41
			A+++	-0.0288291 (0.0207495)	-1.39
Treatment 2 (=1 if the sale is under treatment 2)			**Treatment 2 (=1 if the sale is under treatment 2)**		
A+	0.0030282 (0.0086077)	0.35	C	-.00007728 (0.0014247)	-0.54
A++	0.0291352* (0.0167824)	1.74	B	-0.0146048* (0.0074807)	-1.95
A+++	-0.0321634** (0.0145335)	-2.21	A+	0.0266537* (0.0147529)	1.81
			A++	-0.0513382** (0.0252249)	-2.04
			A+++	0.0400621** (0.0197026)	2.03
Attributes			***Attributes***		
Width (=1 if the size is 600 mm)			**Type of tumble-drier**		
A+	-0.0003214*** (0.000099)	-3.25	Heat pump	--Ref--	
A++	0.0002582 (0.0002049)	1.26	Condensation		
A+++	0.0000632 (0.0001827)	0.35	C	-0.050445 (0.251411)	-0.20
Number of services			B	0.5895717*** (0.045088)	13.08
A+	-0.0583666*** (0.0030191)	- 19.33	A+	-0.0356428 (0.0970795)	-0.37
A++	-0.0322111*** (0.0044579)	-7.23	A++	-0.453649*** (0.1609832)	-2.82
A+++	0.0905777*** (0.0033735)	26.85	A+++	-0.0498348 (0.0394832)	-1.26
Water consumption (L)			Evacuation		
A+	0.0002408*** (9.15e-06)	26.32	C	-0.0401481 (0.251554)	-0.16
A++	0.0000896*** (0.0000166)	5.41	B	0.5412806 (3.242479)	0.17
A+++	-0.0003305*** (0.000014)	- 23.62	A+	-0.0359273 (0.097078)	-0.37
			A++	-0.6543956*** (0.1545897)	-4.23
			A+++	0.1891904 (3.242478)	0.06
Income (in the area where the store is located)			***Income (in the area where the store is located)***		
A+	-4.38e-07 (3.12e-07)	-1.40	C	1.22e-07 (8.62e-08)	1.41
A++	6.28e-07 (5.89e-07)	1.07	B	6.09e-07** (2.55e-07)	2.39
A+++	-1.89e-07 (5.06e-07)	-0.37	A+	-1.73e-07 (2.24e-07)	-0.77
			A++	-6.41e-08 (6.67e-07)	-0.10
			A+++	-4.94e-07 (5.87e-07)	-0.84
RENOVE (=1 if the sale took place at a store where a RENOVE had been run prior to the experiment)			***RENOVE (=1 if the sale took place at a store where a RENOVE had been run prior to the experiment)***		
A+	-0.0054285 (0.0073085)	-0.74	C	-0.0013913 (0.0010103)	-1.38
A++	-0.0523405*** (0.0138966)	-3.77	B	-0.0102351 (0.0063395)	-1.61
A+++	0.057769*** (0.0119158)	4.85	A+	-0.0188231 (0.0141577)	-1.33
			A++	0.0295853 (0.0222896)	1.33
			A+++	0.0008642 (0.0166698)	0.05
Price (€)			***Price (€)***		
A+	-0.0000733*** (0.0000175)	-4.18	C	-0.0000794*** (0.0000268)	-2.97
A++	-0.0007048*** (0.0000253)	- 27.87	B	0.0000248 (0.0000282)	0.88
A+++	0.0007781*** (0.0000187)	41.55	A+	-0.0001563*** (0.0000225)	-6.96
			A++	-0.0013814*** (0.0000383)	- 36.04
			A+++	0.0015924***	55.49

				(0.0000287)	
Number of obs = 9,418 LR chi2(16) = 9068.78 Prob > chi2 = 0.0000 Log likelihood = -4355.2233 Pseudo R2 = 0.5101			Number of obs = 5,881 LR chi2(28) = 7726.48 Prob > chi2 = 0.0000 Log likelihood = -2315.0561 Pseudo R2 = 0.6253		
Standard errors are shown in parentheses					
***, ** and * indicate significance at the 1%, 5% and 10% levels.					

Table 15: Summary of the results of the treatment effect.

		Treatment 1	Treatment 2
Washing-machines	A+++	↓	↓
	A++	↑	↑
	A+	.	.
Fridges	A+++	↓	.
	A++	↑	.
	A+	.	.
Dishwashers	A+++	↓	↓
	A++	↑	↑
	A++	↓	.
Tumble-driers	A+++	.	↑
	A++	.	↓
	A+	.	↑
	B	.	↓
	C	↑	.

3.5.2 Memory effect of a rebate programme (RENOVE)

In some regions a rebate programme called RENOVE had been run before the field experiment took place. This gave us the opportunity to analyse whether such programmes had any impact on the purchase of highly efficient appliances once they had ended. Tables 13 and 14 show that having a RENOVE before the experiment increases the probability of buying A^{+++} appliances and reduces for A^{++} products. In particular, the probability of buying an A^{+++} washing-machine is up by 0.8, for A^{+++} fridges by 4.5% and for A^{+++} dishwashers by 5.7%. In the case of A^{++} appliances, our findings suggest that RENOVE programmes reduce the probability of purchase by 0.7% for washing-machines, 4.4% for fridges and 5.2% for dishwashers. These findings thus suggest that RENOVE programmes do indeed have what we refer to as a "memory effect" after they are over.

This opens up new research question to be explored. Further analysis of this issue is highly relevant since as far as we are aware, there is no mention and no evidence in the literature of such effects or anything similar.

The design of our experiment enables us to test this memory effect in a business-as-usual environment, thanks to the control stores. Sales at the control group can be used to check whether the rebate programme really generates a memory effect. Three out of the 19 control stores had run RENOVE programmes before the experiment.

The appliances subsidised by RENOVE were washing-machines, fridges and dishwashers but the memory effect is also tested for tumble-driers. We believe that including tumble-driers is useful to ensure that there is no *cross-appliance memory effect,* i.e. we strive to ensure that the fact that some appliances are subsidised does not influence consumers to purchase other high-efficiency appliances which are not directly subsidised[29].

The RENOVE only encourages sales of the most energy-efficient appliances (A^{+++}), so we propose a probit model to test the memory effect only using sales of the control group (Cameron et al., 2005). The dependent variable *y* takes a value of 1 when the appliance is A^{+++} and zero otherwise. Thus, we seek to determine whether there is a memory effect and if so whether it nudges purchasers towards the most energy-efficient choices (those subsidised) even after the end of

[29]Where a RENOVE programme was run prior to the experiment, there could have been a cross-appliance memory effect. Such an effect is similar to the cross-subsidisation effect and takes place when a consumer wants to buy two specific appliances only one of which is covered by the RENOVE programme. The subsidy received for the first appliance may enable the consumer to buy a second appliance with a higher efficiency level. However, in the field experiment we are unable to control who is buying each appliance, so we cannot analyse whether such a cross-appliance memory effect exists.

the programme. Specification (6) is for washing-machines, (7) for fridges, (8) for dishwashers and (9) tumble-driers:

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Capacity + \beta_3 TypeofEmbedding + \beta_4 WaterConsumption + \beta_5 Income + \beta_6 Renove + \beta_7 Price + \varepsilon, \quad (6)$$

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Height + \beta_3 VolumeoftheFreezer + \beta_4 Income + \beta_5 Renove + \beta_6 Price + \varepsilon, \quad (7)$$

$$P(y = 1 \mid X) = \beta_1 + \beta_2 Width + \beta_3 NumberofServices + \beta_4 WaterConsumption + \beta_5 Income + \beta_6 Renove + \beta_7 Price + \varepsilon, \quad (8)$$

$$\mathrm{P(y = 1 \mid X) = \beta_1 + \beta_2 Capacity + \beta_3 Revolutions + \beta_4 Income + \beta_5 Renove + \beta_6 Price + \varepsilon,} \quad (9)$$

The results of the marginal effects of (6), (7), (8), and (9) are shown in Table 16. As can be seen, the presence of an earlier RENOVE does indeed positively affect the purchase of high- efficiency washing-machines, fridges and dishwashers, so we find evidence of the so-called *memory effect*. However, we find no evidence of a cross-memory effect in the case of tumble-driers as they were not included in the 2018 RENOVE programme. We also analysed this memory effect month by month but found no clear effects.

It is worth stressing again here that the RENOVE programme ended long before the experiment started. This clearly shows that the programme may still have an effect on the purchase of the most highly-efficient appliances. Several potential explanations for the memory effect found in this study could be suggested. One is that stores know that a rebate programme is due to start on a certain date, so they increase stocks of the most energy-efficient appliances in expectation of a significant increase in the sales of such appliances due to the programme. When the programme ends they may still have a substantial stock of the most energy-efficient appliances, so they continue selling them (maybe even at lower prices) to clear the stock out. A second explanation may be that rebate programmes usually have an intense advertising campaign, so consumers may continue to visit the stores attracted by the RENOVE programme long after the programme itself has ended. Yet another potential explanation is that the stores may continue to offer special prices to keep attracting consumers.

Most papers that analyse the impact of rebate programmes tend to focus on the period when the programme is running. It is unclear from such studies whether rebate programmes are effective and efficient in promoting the purchase of highly energy-efficient products. Mixed results are obtained depending on the country and the product. In fact, in USA it is observed an increase of between 3.3% and 6.6% in sales of highly efficient washing machines, dishwashers, refrigerators and air conditioners due to a rebate program (Datta and Filippini, 2016). On the contrary, other studies show that with rebate programs consumers tend to buy appliances of higher quality but not necessarily more energy-efficient (Houde and Aldy, 2017). Finally, Galarraga et al. (2013) show that the RENOVE rebate programme for dishwashers in Spain generated welfare losses and a rebound effect and had a significant cost.

In spite of these results from the literature, our findings suggest that the impact of RENOVE extends beyond the period when the programme is actually running. Findings in regard to the effectiveness of rebate programmes may thus therefore change if their analysis focuses on a period that extends beyond the end of the programme.

In any case, this memory effect is a very interesting finding that is worth exploring in further research. We believe that further research in greater depth is needed to consider the impacts of rebate programmes in the long run.

Table 16: Evidence for the memory effect based on control sales of the RENOVE programme in Spain

Washing-machines			**Fridges**			**Dishwashers**			**Tumble-driers**		
	Marginal effects	Z		Marginal effects	Z		Marginal effects	z		Marginal effects	z
Capacity (kg)	0.0015584*** (0.0003676)	4.24	**Height (mm)**	0.0008188*** (0. 0000912)	8.98	**Width (=1 if the size is 600 mm)**	0.0001685 (0.0001854)	0.91	**Capacity (kg)**	0.0037924*** (0.0010805)	3.51
Type of embedding (=1 free installation)	0.0076803*** (0.0017512)	4.39	**Freezer Volume (L)**	-0.0060498*** (0.0006533)	-9.26	**Number of services**	0.085433*** (0.0047746)	17.89	**Spin speed (rpm)**	0.0004226*** (0.0000885)	4.78
Water consumption (L)	-1.95e-06*** (4.08e-07)	-4.78				**Water consumption (L)**	-0.0003379*** (0.0000175)	-19.34			
Income (in the area where the store is located)	-1.10e-08 (1.42e-08)	-0.78	**Income (in the area where the store is located)**	-1.61e-06* (8.57e-07)	-1.88	**Income (in the area where the store is located)**	-1.07e-07 (5.42e-07)	-0.20	**Income (in the area where the store is located)**	-7.28e-08* (4.30e-08)	-1.69
RENOVE (=1 if the sale took place at a store where a RENOVE had been run before the experiment)	0.0014371*** (0.0004836)	2.97	**RENOVE (=1 if the sale took place at a store where a RENOVE had been run before the experiment)**	0.0537222*** (0.0185774)	2.89	**RENOVE (=1 if the sale took place at a store where a RENOVE had been run before the experiment)**	0.0513082*** (0.0115189)	4.45	**RENOVE (=1 if the sale took place at a store where a RENOVE had been run before the experiment)**	-0.0013552 (0.0011)	-1.23
Price (€)	0.0031537*** (0.0008616)	3.66	**Price (€)**	0.9088423*** (0.0329011)	27.62	**Price (€)**	0.5144678*** (0.0239864)	21.45	**Price (€)**	0.0001339*** (0.0000285)	4.70
Number of obs = 15,789 LR chi2(6) = 991.47 Prob > chi2 = 0.0000 Log likelihood = -568.02177 Pseudo R2 = 0.4660			Number of obs = 6,977 LR chi2(5) = 1957.13 Prob > chi2 = 0.0000 Log likelihood = -3667.4834 Pseudo R2 = 0.2106			Number of obs = 5,823 LR chi2(6) = 2610.14 Prob > chi2 = 0.0000 Log likelihood = -1990.3871 Pseudo R2 = 0.3960			Number of obs = 4,379 LR chi2(5) = 2988.92 Prob > chi2 = 0.0000 Log likelihood = -852.22941 Pseudo R2 = 0.6368		
Standard errors are shown in parentheses											
***, ** and * indicate significance at the 1%, 5% and 10% levels.											

3.5.3 Caveats and future research

One of the main advantages of conducting a field experiment is that we can test in real-life conditions whether providing monetary information through sales staff and/or a supplementary label is effective in promoting the purchase of high-efficiency appliances. However, there are also some well-known drawbacks inherent in experiments, as it is not always possible to control all factors that affecting them. For instance, the large number of sales and consumers at El Corte Inglés made it really difficult to fully control what information consumers received and how they interpreted it. Not could we control whether consumers who received the information during Treatment 1 actually purchased the appliance at that time or postponed the purchase until Treatment 2 was in place or even until after the Treatments had ended. Other relevant information that we were unable to access included consumer characteristics such as gender, household composition, current disposable income, whether this was a first purchase or a replacement, what final price was paid and/or what other services they obtained together with the appliances such as extra after-sales technical assistance, etc. We are aware that all this information could have been collected via a survey of consumers who bought appliances, but it must be realised that the design of the field experiment had to be adapted to what was reasonable for and doable by the retailer that was collaborating with the research.

Another limitation is that we obtained sales data from the stores only while the experiment was running, i.e. we had no access to sales before and after the experiment. We cannot test the long run effects of our experiment or the memory effect. For instance, we have no clue whether sales staff continue to provide information on LEC.

Apart from the limitations due to the methodology itself, we found another caveat of our study. As the literature does not point out the memory effect, we did not expect to find it and if we are to defend the validity of our field experiment we need to state clearly whether our results might be biased or not by the memory effect.

3.6 Conclusions and policy implications

Encouraging the adoption of energy-efficient appliances is one of the principal challenges that must be tackled if EE targets at EU level are to be achieved. We provide consumers with additional information on energy cost over the lifetime of the appliance. The objective is to test how transforming energy information from physical units (kWh) to monetary units (€) affects the purchase of high-efficiency appliances.

To that end, a field experiment was conducted at 29 El Corte Inglés stores for washing-machines, fridges, dishwashers and tumble-driers. Lifetime energy cost information was given in addition to the existing EE label. Two different treatments were implemented and tested during the field experiment. In the first, monetary information was provided visa sales staff. In the second it was provided via a supplementary label and via sales staff.

The results show that consumer decision-making differs from one product category to another and that different variables play different roles depending on the specific appliances. Therefore, we did not find clear evidence of the effectiveness of monetary information.

We find that providing monetary information is statistically significant and effective in promoting the purchase of A^{++} washing-machines and dishwashers when information is provided by sales staff only or in combination with an additional label. However, none of the treatments help to promote the purchase of A^{+++} washing-machines and dishwashers, and Treatment 1 even decreases the probability of selling A^{+++} fridges. The main reason for the results, in the case of washing-machines, is that the scope for improvement is very small as more than 98% of sales in the control stores are already A^{+++} ones. For tumble-driers, treatment 2 increases the probability of selling those A^{+++} labelled ones while decreasing that of A^{++}.

We also find that technical attributes such as product size, height and number of services are significant and increase the probability of buying an energy-efficient appliance. Heterogeneous effects are found for other attributes such as freezer volume for fridges and water consumption for washing-machines and dishwashers. This indicates that providing LEC information combined with technical attributes may be effective in influencing consumer decision-making depending on the product category.

Heterogeneous impacts are also found for income in the area of purchase. Indeed, in higher-income areas we find a higher probability of buying A^{++} fridges and C-labelled tumble-driers. In the case of washing-machines and dishwashers no link is found between income and the probability of buying energy-efficient appliances. Finally, prices are significant and relevant in the decision-making processes of consumers.

Prior to our experiment, a RENOVE rebate programme was in place for some of the stores. We find that the programme has a positive impact on sales of high-efficiency appliances even after the programme is over. As far as we know, most studies that analyse rebate programmes examine their effectiveness only during their implementation periods. The evidence we find of a memory effect, adds a new dimension to the study of the impact of several economic instruments such as rebates, taxes and/or feebates as far as their positive or negative effects may continue well after they cease to be applied. Looking for evidence for other goods such as housing or vehicles would be a very interesting extension of this research.

In this experiment, we were able to analyse the effectiveness of monetary information thanks to the volume of sales at El Corte Inglés was very high but we could not control other relevant variables (e.g. consumer's income). Moreover, future experimental studies should be conducted to compare the effectiveness of providing monetary information on different scales (lifetime energy savings vs. lifetime energy costs).

A new EE label came in force in March 2021 with a A-G scale to replace the A+++-D scale, even if these new labels offer the energy consumption information per uses (in the case of washing machines and dishwashers), they do not offer any kind of monetary information. It is not clear if the monetary information with this new A-G scale could increase the adoption and the understanding on EE. What does seem evident is that, due to the increase in electricity prices in the Spanish energy market, consumers are more aware of their energy expenditure.

4 Memory effect of appliance rebate programme: evidence from a lab experiment

4.1 Introduction

According to the latest report by the IPCC, the rate of growth of greenhouse gas emissions (GHG) continues to increase and we are already 54% above 1990 levels (IPCC, 2022). Increasing the energy efficiency (EE) level of energy-using goods is important in reducing these emissions, especially in reducing household energy consumption (Dubois et al., 2019; Labandeira et al., 2020; Solà et al., 2020). EE is defined technically as improving the efficiency with which energy is used to provide a service (Linares and Labandeira, 2010). This could have several benefits (cost reduction, reduction in emissions, etc.), but these are not always enough to nudge consumers towards the most energy-efficient choices. Even when EE is financially profitable for consumers, they may not always invest as much as seems rational (Gerarden et al., 2017). This is known as the *energy efficiency gap* and refers to situations in which beneficial investments in EE are not made (Jaffe and Stavins, 1994b).

Several policies, commonly known as EE policies, have been designed to promote the adoption of energy-efficient technologies and reduce the EE gap. They include command and control instruments, financial incentives and information-based instruments (Galarraga et al., 2013; Gerarden et al., 2017; Ramos et al., 2016; Solà et al., 2020).

Consumer decision-making, and therefore the effectiveness of EE policies, is conditioned by the investment and energy literacy of consumers and by other individual behavioural characteristics (e.g. risk aversion). Investment literacy is defined as the ability of consumers to understand financial issues, while energy literacy is the capability to understand energy-related topics (e.g. to understand concepts such as energy consumption). Blasch et al. (2022) run a randomised control trial in Switzerland and find that energy and investment literacy are closely correlated with the probability of investing in energy-efficient choices. Blasch et al. (2019) show that more energy- and investment-literate individuals tend to perform an optimisation process rather than relying on decision-making heuristics.

When making an economically rational choice, consumers usually have to make an investment analysis. To perform such an analysis, particularly for appliances, they have to consider not only the purchasing price but also the running cost of each appliance over its lifetime (Blasch et al., 2019, 2022; Solà et al., 2021a). To make this estimation, consumers must consider the energy consumption of the appliance, its expected lifetime, its frequency of use and energy prices. Estimating the lifetime energy cost of a household appliance thus involves a *deliberation cost*[30]

[30] This is the process of thoughtfully weighing options, usually prior to making a decision or choosing a product.

(Pingle, 2015) or *decision-making cost*[31] (Conlisk, 1988). This is linked to concepts such as bounded rationality: in other words, processing and understanding information is costly for individuals.

In assessing the effectiveness of EE policies the main financial incentives studied in the literature are taxes, subsidies and rebate programmes. We focus mainly on rebate programmes here, defined as small-scale instruments such as subsidies for energy-efficient products. The objective of rebate programmes is to subsidise the replacement of products by new, more energy-efficient models. Governments have introduced various rebate policies for increasing the adoption of energy-efficient products, such as the RENOVE plan for appliances in Spain (Galarraga et al., 2013) and the State Energy-Efficient Appliance Rebate Programme in the USA (Houde and Aldy, 2017).

The evidence as to how effective rebate policies are in increasing the acquisition of energy-efficient appliances is not conclusive. Some studies show that the effect may be positive (Datta and Filippini, 2016) while others show that effectiveness depends on the product category (Chuang et al., 2018) and on other variables such as income, risk and time preferences (Galarraga et al., 2013; Houde and Aldy, 2017; Olsthoorn et al., 2017).

Datta and Filippini (2016) analyse the effectiveness of the Energy Star rebate policy programme in the USA for washing-machines, dishwashers, refrigerators and air conditioners. They find an increase of between 3.3% and 6.6% in sales of highly energy-efficient appliances as a consequence of the programme. Chuang et al. (2018) find that rebate programmes in Southern California can be effective depending on the product category. They find that this programme is responsible for a reduction in energy consumption by pool pumps (12%) and refrigerators (6%), lighting and HVAC based on the EE label. But for dishwashers and washing-machines average energy consumption increases.

Other studies note that the effectiveness of rebate programmes is not assured. Houde and Aldy (2017) show that in the presence of a rebate programme consumers tend to buy appliances that are of higher quality but not necessarily more energy-efficient. Galarraga et al. (2013) show that the RENOVE rebate programme for dishwashers in Spain generated welfare losses and a rebound effect. Similarly, Olsthoorn et al. (2017) show that the effectiveness of rebate

[31] This is the process of obtaining the best price for a product with no impact on service.

programmes across 8 EU Member States is affected by the income, risk and time preferences of recipients.

A new effect called the *RENOVE memory effect* (hereafter just *memory effect*) is found in a field experiment in Solà et al. (2021b). The experiment was run in Spain and designed to analyse the effectiveness of providing consumers with monetary information on appliances. The results show that in those places where a RENOVE programme was running before the experiment, the effect of the RENOVE lingered after the end of the programme. The presence of the memory effect shown in Solà et al. (2021b) opens a new space for debate concerning the effectiveness of rebate programmes. So far, studies have focused only on analysing the policy implementation period, but the fact that the effect of the RENOVE programme lasts beyond the end of the programme raises the question of whether the same happens for other policies or with other product categories.

The this study reported here sets out to test the results obtained in Solà et al. (2021b), i.e. to analyse in a controlled environment[32] whether there is a memory effect and what factors nudge consumers' purchasing decisions towards energy-efficient appliances. To address this issue, we consider different risk framings and other personal factors (e.g. recent experiences buying appliances) that could lead to different decisions.

The rest of the chapter is structured as follows: Section 4.2 explains the design of the lab experiment, giving details on the risk framing and role-playing exercises and the post-experiment survey. Section 4.3 sets out the model specification and Section 4.4 discusses the results. Section 4.5 provides the main conclusions of the study and some policy recommendations.

4.2 Design of the Experiment

A lab experiment was run to check for any memory effect of the RENOVE programme and the factors promoting it in a controlled environment. This experiment took place at the Bilbao Laboratory of Experimental Analysis (Bilbao-Labean[33]) at the University of the Basque Country, in a computer-based form using z-Tree software, in March 2022. Subjects were recruited in

[32] We acknowledge that from the summer of 2021 and particularly from the start of the war in Ukraine, there has been a significant increase in energy prices (particularly in the case of gas and electricity).
[33] Official website: https://www.bilbaolabean.com/index.php?pag=13

Bilbao area by the independent company CPS[34]. This company was responsible for selecting subjects according to age, gender, social class and occupation.

166 subjects took part in the experiment, in 4 different sessions. Table 17 shows their socio-demographic characteristics: 54.22% were women, 44.58% men and 1.20% were individuals who did not identify with either gender. Their average age was 44, with the youngest subject being 19 and the oldest 69. 49.40% of the subjects had a university degree or vocational training qualification, 15.66% had upper secondary education and 13.86% basic secondary education. The rest had basic education (9.64%), a master's degree (10.24%) or a PhD (1.20%). Another interesting characteristic connected to education is social class. When asked about their social class, 46.39% of the subjects self-classified as middle class. It is important to note that this is their own opinion of their situation. Subjects were also asked whether they took part in environmental organisations and only 16.27% said yes.

Table 17: Distribution of subjects by socio-demographic characteristics

Gender	%
Male	44.58%
Female	54.33%
Other	1.20%
Education level	%
Basic education	9.64%
Secondary education	13.86%
Upper secondary education	15.66%
University degree or vocational qualification	49.40%
Master's degree	10.24%
PhD	1.20%
Social class	%
Upper	.
Upper-middle–	7.83%
Middle	46.39%
Lower-Middle	27.11%
Lower	18.67%
Participation in environmental org	%
Yes	16.27%
No	83.73%

At the beginning of each session, subjects were provided with written general instructions which were read aloud to ensure that they understood the structure of the session. These instructions (see A6 in *Annex-Chapter 4*) informed them that this lab experiment comprised 3 different parts: (i) a risk-elicitation task to measure subject preferences; (ii) a role-playing exercise to analyse whwther there is a memory effect in the purchasing decision for a fridge; (iii) a post-experiment

[34] CPS – Estudios de Mercado y Opinión, https://www.cps2000.com/.

survey to control for differences in decision-making and explain their decisions and other personal factors (e.g. socio-demographic factors).

4.2.1 Risk elicitation task

To analyse the risk preferences of subjects, we used the risk elicitation task developed by Falk et al. (2016) and extended by Markanday et al. (2022) (see A5 in *Annex-Chapter 4*). This exercise entailed a staircase risk procedure to analyse the risk aversion of subjects. They had to make five independent choices between a lottery and a sure payment. The lottery was the same in all decisions, while the sure payment changed in each decision depending on how risk averse or risk-loving the subject was. This procedure generated risk scores between 1 (higly risk-averse) and 31 (highly risk-loving). The score for each subject was estimated according to the switching row, i.e. the point where the subject preferred the sure payment to the lottery.

4.2.2 Role-playing exercise

Subjects were asked to purchase a fridge for their main dwelling in four different scenarios (see Figure 5). As shown in Figure 5, subjects had to choose between a non-efficient fridge (hereafter *INEF*) and an efficient fridge (hereafter *EF*) with information on the range where energy prices would be and the lifetime of fridges, and then with specific information on both fridges (energy consumption[35] and purchasing price).

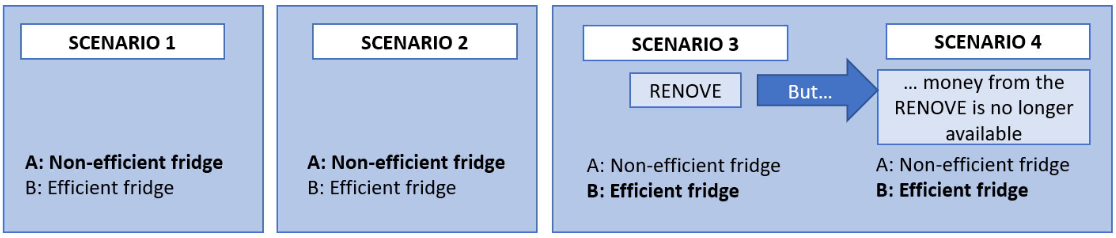
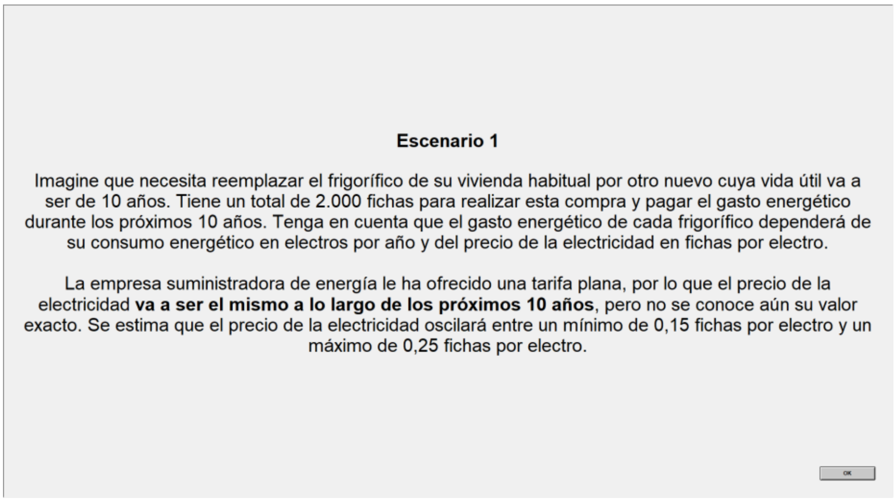


Figure 5: Diagram of the role-playing game

We controlled these variables so that all subjects had the same context (see Figure 6). We set the energy consumption and price based on Solà et al. (2021b, 2021a). In the case of the energy price, subjects only knew the upper and lower bounds. In order to introduce uncertainty in the decision-making, the energy price was randomly chosen within that range. Given that consumers usually believe that their next appliance will last as long as the previous one, and to

[35]Waechter et al. (2015a) point out that consumers usually misunderstand and mix up concepts like EE and energy consumption. In order to avoid this potential misunderstanding, for this study the *EF* fridge has a lower energy consumption than the *INEF* fridge.

avoid widespread awareness of planned obsolescence, we assume a 10-year lifetime, as in Solà et al. (2021b, 2021a) and Kallbekken et al. (2013).



In English:

Scenario 1

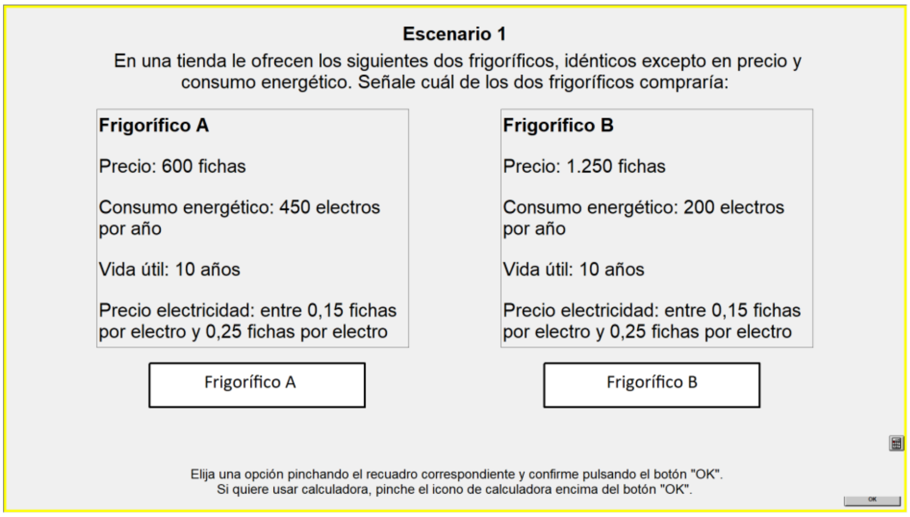
Imagine that you need to replace the fridge at your usual residence. The new one will have a useful lifetime of 10 years. You have a total of 2000 tokens with which to buy the appliance and pay for the energy that it uses over the next 10 years. Bear in mind that the energy cost of each fridge will depend on its energy consumption in electros per year and the price of energy in terms of tokens per electro.

The power company offers a flat rate, so the price of electricity will remain the same for the next 10 years, but its exact level is not yet known. It is estimated that electricity prices will vary between a minimum of 0.15 tokens per electro and a maximum of 0.25.

Figure 6: Screenshot with the explanations of the purchasing context.

The budget in each scenario was the same for all subjects (2000 tokens). With this budget, they had to pay the price of the product and the potential lifetime energy cost (LEC) of the fridge chosen. Subjects were not told the final outcomes until the end of the role-playing exercise, to avoid any decision bias.

In Scenario 1, subjects had to choose between fridges A and B. This could be considered a control question (see Figure 7).



In English:

Scenario 1 A shop offers the following two fridges, which are identical except for their prices and energy consumption. Please indicate which you would purchase:	
Fridge A Price: 600 tokens Energy consumption: 450 electros per year Useful lifetime: 10 years Electricity price: between 0.15 and 0.25 tokens per electro	Fridge B Price: 1250 tokens Energy consumption: 200 electros per year Useful lifetime: 10 years Electricity price: between 0.15 and 0.25 tokens per electro
Fridge A	Fridge B
Choose an option by clicking on the appropriate box and confirm by clicking OK. If you wish to use a calculator, click on the calculator button above the OK button.	

Figure 7: Screenshot of fridge selection in Scenario 1. Fridge A on the left is INEF while Fridge B on the right is EF.

In Scenario 2 they had to repeat the same decision, but in this case subjects knew how many tokens were left after paying for the chosen fridge and the LEC. In this scenario, we wanted to overcome any potential miscalculations by subjects when estimating the LEC and other biases (e.g. subjects knew that they were in a lab experiment and they might have answered what they believed was expected).

In Scenario 3 subjects again made their purchasing decisions, with the only difference that in this case a RENOVE rebate programme was running. The objective of this programme was to encourage the replacement of old appliances by new, more efficient ones (Galarraga et al., 2013) so a discount of 150 tokens was offered to those subjects who choose the efficient fridge. Once subjects decided, they moved on to Scenario 4. In this scenario, a message appeared on the screen indicating that the RENOVE rebate programme had ended, and they had to decide whether to maintain their choice between the same two fridges (see Figure 5).

Table 18 shows the percentage of subjects who chose efficient fridges per scenario. 60.24% chose *EF* in Scenario 2. In Scenario 3 (with the RENOVE) this figure increased to 89.75% and then once the RENOVE was over it dropped to 66.86%.

Table 18: % of efficient fridges per scenario.

% subjects who chose efficient fridges per Scenario	%
Scenario 1	75.90%
Scenario 2	60.24%
Scenario 3	89.75%
Scenario 4	66.86%

Once all subjects had finished the role-playing exercise, final payments were shown on the screen. To help understand subjects' decision-making, just after this message on final payments we asked whether the main criterion underlying each choice in each scenario was based on the price of the two options, on energy consumption, on lifetime energy cost or on a random decision. We acknowledge that the responses could be biased by each subject's perspective, but this information could be useful in understanding subjects' decision-making.

4.2.3 Post-experiment survey

A post-experiment survey was conducted to control for subjects' characteristics, such as socio-demographic aspects and environmental concern. This survey was divided into 4 parts (see A7 in *Annex-Chapter 4*): (i) Difficulty of the lab experiment (Questions 1 and 2); (ii) Personal experience regarding EE and the RENOVE rebate programme (Questions 3 to 8); (iii) Attitudes towards the environment (Questions 9 to 11); and (iv) Socio-demographic characteristics (Questions 12 to 18).

"Difficulty of the lab experiment" was intended to check how hard the subjects found the task. Subjects were asked to rate the complexity of the role-playing game (from 1 to 5) and about their feelings during the experiment (e.g. nervous, excited). These questions could be useful for contextualising the results (i.e. we can learn whether the subject understood the exercise correctly).

Questions 3 to 8 were designed to find out whether subjects had recently bought an appliance and how much they knew about EE. Then subjects were asked about their attitude towards the environment. According to Ramos et al. (2016), environmentally friendly consumers tend to invest more in energy-efficient appliances than those not interested in environmental problems.

Finally, we asked about socio-demographic characteristics (e.g. age, gender) as they could affect EE investments (Jones and Lomas, 2015).

4.2.4 Payments

The experiment was incentivized so that subjects could experience real gains in the risk elicitation task and in the role-playing exercise. In the former, subjects could earn a maximum of 150 tokens, while in the latter they had to choose between two fridges with a budget of 2000 tokens and the final payments depended on (i) the decision made in each scenario; (ii) the scenarios chosen for the payment; and (iii) the final energy price. Two scenarios and energy prices were randomly selected in each session, and were the same for the subjects in each session. Because they were randomly selected, no-one knew what the final payment to subjects would be until the end of each session.

To maximise transparency, subjects were informed of the value of tokens in € (200 tokens = €1). Subjects also received €15 for participating. The minimum payment was €17.65 and the maximum €23. All these points were read aloud in the instructions before the experiment started (see A6 in *Annex-Chapter 4*).

4.3 Model specification

We seek to explain each set of decisions given the decisions of the subjects throughout the scenarios. We use binary response models to analyse the data, so the dependent variable can only take a value of zero or one. This enables us to estimate the factors that affect different consumers' choices, and thus identify the characteristics that affect the probability of buying an energy-efficient appliance in different contexts. These models are specified as follows (Cameron and Trivedi, 2010):

Assume that y^* is a latent variable which follows $y^* = X\beta + e$, where X is the $1 \times K$ vector, β is a $K \times 1$ vector of parameters, e is independent of X and $e \sim$ Normal (0,1).However, instead of y^*, only a binary variable indicating the sign of y^* is observed:

$$y = \begin{cases} 1 & if y^* > 0 \\ 0 & if y^* \leq 0 \end{cases}$$

In binary response models, the interest lies in the response probability:

$$P(y = 1 \mid X) = P(y^* > 0 \mid X) = P(e > -X\beta \mid X) = 1 - G(-X\beta\,) = G(X\beta\,) \equiv p(x)$$

where G is the cumulative distribution function of a standard normal density function (called a probit model). G can also be the cumulative distribution of a logistic function.

The probit model used can be expressed as $P(y = 1 \mid X)$, where y will express the dependent variable and *X* contains the explanatory variables referring to the *personal characteristics* of the subjects (gender, age, etc.) and the *experimental variables* (how subjects are feeling during the lab, the difficulty of the exercise, etc.) defined as:

$$\Pr(y|X) = \beta_0 + \sum_{i=1}^{n} \beta_i \, PersonalCharacteristics_i + \sum_{j=n+1}^{m} \beta_j \, ExperimentalVariables_j + \varepsilon$$

Thus, β_i and β_j capture whether $PersonalCharacteristics$ and $ExperimentalVarables$, respectively, increase or decrease the probability of buying EF or INEF fridges under different scenarios.

We ran different models with different dependent variables. Table 19 presents the number of subjects for each set of choices and potential explanations for those choices: 51.20% of the subjects always bought an efficient fridge, while 12.65% only bought an energy-efficient fridge when a RENOVE programme was running.

The pure memory effect is represented by *INEF*, *INEF*, *EF*, *EF* choices in Scenarios 1 to 4 respectively, and the hybrid memory effect by *EF*, *INEF*, *EF*, *EF*[36]. This could be also considered a memory effect as subjects could choose an efficient fridge because they miscalculate the LEC. It can be seen that 13.25% of the subjects show a memory effect (9.64% hybrid and 3.61% pure memory effect).

Thus, 6.02% of the subjects always bought an inefficient fridge. The remaining sets of choices are not so common and it is not easy to provide an explanation for them. So, considering the distribution shown in Table 19, we define 4 variables that are considered as dependent based on the set of choices made by the subjects (highlighted in bold in Table 18): *Renove* (which takes a value of 1 if the subject chose *INEF, INEF, EF, INEF*); *MemoryEffect* (a value of 1 if the subject

[36] The pure memory effect is considered when the subject chose INEF in Scenarios 1 and 2, and then in Scenario 3 and 4 bought EF with no need for further information. In the case of the hybrid memory effect, subjects chose EF in Scenario 1 and then, once they received additional information, changed their decision to INEF in Scenario 2 (and EF in Scenario 3 and 4). In this case, subjects need the additional information before they buy an INEF fridge in Scenario 2.

chose *EF, INEF, EF,EF* or *INEF,INEF,EF,EF*); AlwaysEfficient (a value of 1 if the subject chose *EF,EF,EF,EF*) and *AlwaysInefficient* (a value of 1 if the subject chose *INEF, INEF, INEF, INEF*).

Table 19: Distribution of subjects' choices per Scenario

Purchasing decision per Scenario				Interpretation	Total	%
Scenario 1	Scenario 2	Scenario 3	Scenario 4			
EF	***EF***	***EF***	***EF***	**Environmentally friendly**	**85**	**51.20%**
INEF	***INEF***	***EF***	***INEF***	**RENOVE effect - Investment in EE with RENOVE**	**21**	**12.65%**
EF	***INEF***	***EF***	***EF***	**Hybrid memory effect**	**16**	**9.64%**
INEF	***INEF***	***EF***	***EF***	**Pure Memory effect**	**6**	**3.61%**
INEF	***INEF***	***INEF***	***INEF***	**Sceptical consumer**	**10**	**6.02%**
EF	*INEF*	*EF*	*INEF*	Miscalculation in Scenario 1 and investment in EE with the RENOVE	9	5.42%
EF	*EF*	*EF*	*INEF*	?	10	6.02%
EF	*INEF*	*INEF*	*INEF*	?	3	1.81%
EF	*EF*	*INEF*	*EF*	?	2	1.20%
INEF	*EF*	*EF*	*EF*	?	1	0.60%
INEF	*EF*	*EF*	*INEF*	?	1	0.60%
EF	*EF*	*INEF*	*INEF*	?	1	0.60%
INEF	*INEF*	*INEF*	*EF*	?	1	0.60%

As can be seen in equations (1)-(4), we include different explanatory variables grouped under *personal characteristics* such as *Gender* (which takes a value of 1 if the subject is male), *Age* (which takes the value of the age of the subject), *PeopleHome* (which takes the value of the number of people living in the subject's household), *Education* (1 if the subject has a Bachelor's, Master's or PhD degree), *SocialClass* (the social class of the subjects, i.e. upper, upper middle, middle, lower-middle or lower), *RiskLover* (which takes a value of 1 if the subject is a risk lover), *RiskAverse* (1 if the subject is risk-averse), *EnvironmentalConcern* (1 if the subject is highly concerned about the environment), *EnvironmentalOrg* (1 if the subject is enrolled in an environmental organisation) and *Appliance* (1 if the subject has bought an appliance for their dwelling in the last 4 years).

Other variables grouped under *experimental variables* are also included in the model: *Interested* (which takes a value of 1 if the subjects feel interested during the lab experiment), *Excited* (1 if the subject feels excited during the lab experiment), *Nervous* (1 if the subject feels nervous during the lab experiment), *FutureGenerations* (1 if the subject agrees with the statement: "Future generations will be the ones who will have to deal mainly with environmental problems"), *Difficulty* (1 if the subject thinks that the exercise was difficult or very difficult), *ConsumptionCriteria* (1 if the subject makes choices during the scenarios by considering mainly the attribute of energy consumption), *LifetimeEnergyCostCriteria* (1 if the subject makes choices during the scenarios by considering mainly the LEC of each fridge) and *RandomCriteria* (1 if the subject makes choices during the scenarios randomly).

The descriptive statistics of the variables used in (1) to (4) are shown in A8 in *Annex-Chapter 4:*

$$\Pr(y|x) = \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 PeopleHome + \beta_4 Education + \beta_5 SocialClass + \beta_6 RiskLover + \beta_7 RiskAverse + \beta_8 EnvironmentalConcern + \beta_9 EnvironmentalOrg + \beta_{10} Appliance + \beta_{11} Interested + \beta_{12} Nervous + \beta_{13} FutureGenerations + \beta_{14} Difficulty + \beta_{15} ConsumptionCriteria + \varepsilon \quad (1),$$

$$\Pr(y|x) = \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 PeopleHome + \beta_4 Education + \beta_5 SocialClass + \beta_6 EnvironmentalConcern + \beta_7 EnvironmentalOrg + \beta_8 Appliance + \beta_9 Interested + \beta_{10} Excited + \beta_{11} Nervous + \beta_{12} FutureGenerations + \beta_{13} ConsumptionCriteria \beta_{14} LifetimeEnergyCostCriteria + \varepsilon \quad (2),$$

$$\Pr(y|x) = \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 PeopleHome + \beta_4 Education + \beta_5 SocialClass + \beta_6 RiskLover + \beta_7 RiskAverse + \beta_8 EnvironmentalConcern + \beta_9 EnvironmentalOrg + \beta_{10} Appliance + \beta_{11} Interested + \beta_{12} FutureGenerations + \beta_{13} LifetimeEnergyCostCriteria + \beta_{14} RandomCriteria + \varepsilon \quad (3),$$

$$\Pr(y|x) = \beta_0 + \beta_1 gender + \beta_2 age + \beta_3 PeopleHome + \beta_4 Education + + \beta_5 RiskLover + \beta_6 RiskAverse + \beta_7 EnvironmentalConcern + \beta_8 EnvironmentalOrg + \beta_9 Appliance + \beta_{10} Interested + \beta_{11} FutureGenerations + \beta_{12} LifetimeEnergyCostCriteria + \varepsilon \quad (4).$$

4.4 Results and discussion

In this section we analyse the factors affecting consumers' choices, particularly those that promote the memory effect. The various probit models described in Section 4.3 (Equations 1-4) are set out and discussed. The probabilistic models (1), (2), (3) and (4) were estimated using STATA version 16. Table 20 shows the marginal effects of the models and Table 21 gives a visual outline of the results.

Sections 4.4.1 and 4.4.2 discuss and contextualise the results for Models 1 and 2 and Models 3 and 4, respectively, while section 4.4.3 takes those variables that are significant in all the models and discusses them together.

4.4.1 Which factors nudge consumers towards energy-efficient appliances while a RENOVE is running? Is there a memory effect?

For Model 1, we find that age has a negative effect on the probability of consumers being nudged towards the efficient option with a RENOVE rebate programme. As pointed out in Solà et al (2021a), consumers in the range age of 30 to 45 seem to invest less in high-efficiency fridges. The potential explanation given in Solà et al (2021a) is that those consumers are of an age to be raising children and therefore have less income available to invest in EE. As shown, those subjects who feel interested in the experiment may be more likely to show this effect. One potential explanation is that people who are interested in a task generally concentrate more, and are therefore more susceptible to the small changes arising in each scenario. In fact, a careful, rational study of each scenario shows that Scenarios 1, 2 and 4 involve the same cognitive process, while in Scenario 3 the RENOVE effect changes the context.

Another relevant factor that affects consumer decision-making is recent experience in buying an appliance. Having bought an appliance for their home in the last 4 years increases the probability of consumers being nudged towards an efficient fridge while the RENOVE programme is running. This could be because those subjects who have bought an appliance recently still have all the explanations by sales staff fresh in their memories (Jones and Lomas, 2015). Therefore, they may care more about some attributes (for example, energy consumption and its associated lifetime energy cost). Subjects who make choices in each scenario using the lifetime energy cost criteria are 9.8% more likely to be nudged towards the efficient fridge while a RENOVE is running.

For Model 2, where factors that promote the memory effect are analysed, we find that under the personal characteristics heading education level, social class and environmental concern are the statistically significant variables. Indeed, it seems that the higher their education level is, the more likely subjects are to be affected by the RENOVE after it has expired. In the case of social class, lower-middle class subjects are more likely to be affected by the memory effect. The literature reports a strong correlation between income and investment in EE. Indeed, Filippini et al. (2021) state that credit and liquidity constraints could affect investment in EE, as more energy-efficient options tend to be more expensive. The additional investment required could therefore only be affordable for higher-income individuals.

Similarly, there is more likelihood of a memory effect affecting subjects with high levels of environmental concern. In fact, the literature states that environmental variables could be a good predictor of investment in EE (Trotta, 2018). Ramos et al. (2016) also point out that more environmentally concerned households tend to invest more in energy-efficient technologies. These variables (education, social class and environmental concern) are linked, as individuals with higher education levels usually also have higher income levels, and therefore higher levels of environmental concern. Thus, as shown in Table 20, a lower probability of a memory effect is found in subjects who feel interested in the experiment.

Just before the post-experiment survey, subjects were asked about the main criteria that they had used to make decisions in each scenario. The results show that those subjects who answered that their main criterion was energy consumption are more likely to have the memory effect. Those who mainly care about energy consumption seem always to invest in those options which consume less energy (in this experiment, the lower-consuming fridge is the most efficient one).

Summing up, Model 1 (which analyses the factors that encourage subjects to change their decision from an inefficient fridge to an efficient one with the RENOVE programme) and Model 2 (which analyses those which cause the effect of RENOVE to linger after the scheme expires) show that age, education, social class and environmental concern seem to be relevant for nudging people towards making these decisions. So the effectiveness and the effects of rebate policies could vary from one individual to another. In the literature, the effectiveness and potential effects of rebate policies have mainly been analysed during the running period of the policy and analyses are conducted in general, without differentiating between consumer profiles (Chuang et al., 2018; Galarraga et al., 2013; Houde and Aldy, 2017). In this regard, our study opens up a new question regarding the effectiveness of rebate policies: are they effective for some part of society? Are they really effective in promoting the acquisition of energy-efficient appliances not only during the scheme but also once it is over? The answer to these questions is yes.

Table20: Marginal effects of Model (1) - (4).

Variables	MODEL 1- RENOVE		MODEL 2 – Memory effect		MODEL 3 – always efficient		MODEL 4 – always inefficient	
	Marginal effects	z	Marginal effects	z	Marginal effects	z	Marginal effects	z
Gender (=1 if the subject is male)	0.0374435 (0.0271603)	1.38	-0.0346063 (0.0528432)	-0.65	-0.0505469 (0.0927407)	-0.55	**0.0401826*** **(0.0237633)**	**1.69**
Age	**-0.00239*** **(0.0013791)**	**-1.73**	0.0015412 (0.0022308)	0.69	**0.0077615*** **(0.004124)**	**1.88**	-0.0010658 (0.0010186)	-1.05
PeopleHome	0.0206309 (0.0155058)	1.33	-0.0348844 (0.0263735)	-1.32	-0.0027961 (0.0453796)	-0.06	-0.0093976 (0.0111091)	-0.85
Education (=1 if the subject holds a Bacelor's , Master's or PhD degree)	-0.0127729 (0.0312079)	-0.41	**0.1169006*** **(0.0620943)**	**1.88**	-0.0998195 (0.1011883)	-0.99	-0.0181992 (0.0212454)	-0.86
SocialClass								
Lower middle	0.0567254 (0.038046)	1.49	**-0.1611262**** **(0.0805291)**	**-2.00**	0.075307 (0.1357736)	0.55		
Middle	0.0292781 (0.0238578)	1.23	-0.0856762 (0.0829525)	-1.03	**0.2327231*** **(0.1264877)**	**1.84**		
Upper middle	0.057572 (0.07919)	0.73	-0.0983892 (0.1104725)	-0.89	0.0353253 (0.2034611)	0.17		
RiskLover (=1 if the subject is a risk lover)	-0.0149361 (0.0329894)	-0.45			0.0013197 (0.1091984)	0.01	0.0300463 (0.0251705)	1.19
RiskAverse (=1 if the subject is risk-averse)	0.0186073 (0.034607)	0.54			0.1203321 (0.1098915)	1.10	0.0106162 (0.0261606)	0.41
EnvironmentalConcern (=1 if the subject is highly concerned about the environment)	-0.0592757 (0.041676)	-1.42	**0.1547471**** **(0.0756408)**	**2.05**	0.0853811 (0.1226522)	0.70	-0.0126063 (0.0272957)	-0.46
EnvironmentalOrg (=1 if the subject takes part in an environmental organisation)	-0.0042434 (0.032657)	-0.13	-0.0727788 (0.0710509)	-1.02	-0.0200911 (0.1257927)	-0.16	-0.0143196 (0.0270963)	-0.53
Appliance (=1 if the subject has bought an appliance in the last 4 years)	**-0.0527857*** **(0.0300081)**	**-1.76**	-0.0391263 (0.0552374)	-0.71	0.1322801 (0.1022206)	1.29	-0.0273449 (0.022984)	-1.19
Interested (=1 if the subject feels interested in the experiment)	**0.0748845*** **(0.0422676)**	**1.77**	**-0.1114408*** **(0.062918)**	**-1.77**	0.0602908 (0.1056415)	0.57	-0.0423164 (0.028063)	-1.51
Excited (=1 if the subject feels excited about the experiment)			0.0372578 (0.0588423)	0.63				
Nervous (=1 if the subject feels nervous about the experiment)			-0.167776 (0.1139745)	-1.47	0.0893981 (0.1810481)	0.49		
FutureGenerations (=1 if the subject agrees with the statement "Future generations will be the ones who will have to deal with environmental problems")	-0.0352842 (0.0393579)	-0.90	**0.1492746***** **(0.0568914)**	**2.62**	0.0185457 (0.1144941)	0.16	-0.0305531 (0.029616)	-1.03
Difficulty (=1 if the subjects think that the experiment was difficult or very difficult)					-0.0380307 (0.09834)	-0.39		
ConsumptionCriteria (=1 if subjects make choices during the scenarios considering mainly the energy consumption criteria)			**-0.1337564**** **(0.0680757)**	**-1.96**	**0.4704775***** **(0.099288)**	**4.74**		
LifetimeEnergyCostCriteria (=1 if subjects make choices during the scenarios considering mainly lifetime energy cost criteria)	**0.0985732**** **(0.0411898)**	**2.39**	0.0025567 (0.0627744)	0.04			**0.0550345*** **(0.0288591)**	**1.91**
RandomCriteria (=1 if subjects make choices during the scenarios considering mainly random criteria)							**0.1389705*** **(0.0727298)**	**1.91**
	Number of obs = 164 LR chi2(15) =42.72 Prob > chi2 =0.0002 Log likelihood = -39.450006 Pseudo R2=0.3513		Number of obs=164 LR chi2(16) =28.04 Prob > chi2= 0.0313 Log likelihood = -48.737591 Pseudo R2=0.2234		Number of obs=164 LR chi2(17) =50.28 Prob > chi2= 0.0000 Log likelihood =-88.42531 Pseudo R2=0.2214		Number of obs=164 LR chi2(13) =18.12 Prob > chi2=0.1530 Log likelihood = -28.601451 Pseudo R2= 0.2406	
Standard errors are shown in parentheses ***, ** and * indicate significance at the 1%, 5% and 10% levels.								

4.4.2 What factors promote investment or underinvestment in energy-efficient appliances?

The factors that promote efficient or inefficient choices include gender, age and social class. As shown in Table 20 for Model 3, age increases the probability of always buying efficient appliances and middle-class individuals are also more likely always to make efficient choices (older individuals tend to have more income and therefore be of higher social class). Moreover, recent studies in Spain show that energy-efficient appliances tend to be in general more expensive than less efficient ones (Solà et al., 2021a). Another interesting factor that positively affects investing always in efficient products is the attribute on which subjects focus most. Model 3 shows that those subjects who mainly focus on energy consumption information tend to invest more in energy-efficient options.

Finally, Model 4 shows the factors that nudge individuals towards non-efficient choices. The results shown indicate that males are more likely to choose inefficient options. This could be because there is a gender gap in energy-related literacy (Blasch et al., 2021). In addition, those who make choices randomly in the scenarios are 13.89% more likely always to make inefficient choices.

4.4.3 Age, social class and decision criteria

Table 20 shows some variables that are statistically significant in different models, such as age, social class and decision criteria. We briefly summarise these variables in Table 21.

Age has a negative impact in Model 2 (RENOVE effect) but a positive impact in Model 3 (always efficient). This means that the older the subject is, the more likely they are to buy efficient fridges and the less likely it is that RENOVE will have any effect. This could have a simple explanation: older people tend to be financially better off and can therefore invest more in EE. Another statistically significant variable is social class: in other words those subjects with lower social class are less likely to invest in EE for fridges.

Another interesting variable is that of the decision criteria behind the choices made in the lab experiment. The design of the lab experiment shows that whichever criterion is used is significant in all the choices made. Some subjects based their decision-making on energy consumption criteria, which is positive for the acquisition of efficient fridges, but the same criteria decrease the likelihood of there being a memory effect. Another underlying criterion is lifetime energy cost estimations, and some subjects make choices according to random criteria.

As can be seen in Table 21, lifetime energy consumption criteria promote two choices: buying efficient appliances when RENOVE is running and always buying inefficient ones.

Table 21: A visual outline of the results (+ for those with positive impact and - for those with negative impact)

Variables		**Model 1 - RENOVE**	**Model 2- Memory effect**	**Model 3 - Purchase of an efficient appliance**	**Model 4 - Purchase of an inefficient appliance**
Gender					+
Age		-		+	
Education			+		
Social class	*Middle*			+	
	Lower middle		-		
Environmental concern			+		
Recent purchase of an appliance		-			
Decision criteria	*Energy consumption criteria*		-	+	
	Lifetime energy cost criteria	+			+
	Random criteria				+

4.5 Conclusions

Promoting the adoption of energy-efficient technologies is particularly crucial for reducing energy demand, and so is implementing effective EE policies. One such policy instrument is rebate programmes. This study looks at the factors that promote the memory effect of such programmes and analyses other factors that could nudge consumers towards efficient appliances (particularly fridges, which are one of the highest energy-consuming appliances in households).

In a lab experiment with 166 subjects in a controlled environment, we used various models to study what factors nudge consumers towards two different fridges (a non-efficient fridge, A, and an efficient fridge, B) in different scenarios. All subjects had the following information: the energy consumption and purchase price of each fridge, the range within which energy prices will move and a 10-year useful lifetime for fridges. With a budget of 2000 tokens, subjects had to pay the price of the fridge and its associated LEC.

The results of this study show that different personal characteristics and experimental variables can affect consumers' choices. The probability of there being a memory effect increases among subjects who have a PhD, Master’s or Bachelor’s Degree and when the subject shows high levels of environmental concern. The decision criteria increase the probability of investing in EE while a rebate programme is running, but a recent purchase of an appliance decreases that probability. In the case of efficient decisions, the models show that age, social class and decision criteria are the factors that nudge subjects towards efficient options. Finally, factors such as gender and decision criteria can influence the purchase of non-efficient fridges.

The design of the experiment means that we can identify which factors may promote different decisions, and thus distinguish which type of consumer tends to invest more (or less) in EE. We were able to identify which types of consumer (and for which behavioural characteristics) the RENOVE rebate programme was effective in increasing the adoption of energy-efficient technologies. Age, social class and the criteria underlying each decision seem to be factors that are highly relevant in all choices. On the one hand, age seems to have a positive impact on the probability of buying energy-efficient fridges and a negative impact on the RENOVE effect (i.e. the older the consumer is, the less sensitive they are to the RENOVE rebate programme). Another factor that affects consumer decision-making is social class. The higher the social class (or income), the greater the probability of consumers being nudged towards energy-efficient fridges. As mentioned above, the criteria underlying subjects' decision is also important. As the results show, there are various criteria. Some subjects care mainly about energy consumption while others make choices according to the LEC.

The effectiveness of EE policies, and particularly rebate policies, is usually analysed without taking consumer profiles into account. This study enables a more general perspective on the factors conditioning consumers to invest (or not) in EE to be drawn up. An interesting question for further analysis is whether the current increases in energy price in society are really encouraging consumers to invest in EE.

5 Conclusions

As explained above in this thesis, the household sector accounts for 36.4% of total European energy consumption (followed by industry at 29%), so it is a focal point for reducing GHG emissions (IPCC, 2022). EE is one of the measures proposed for reducing household energy consumption (Linares and Labandeira, 2010; Ramos et al., 2015) and EU is committed to improving EE by at least 32.5% by 2030 under the revised Energy Efficiency Directive (2018/2002). Unfortunately, there is often underinvestment in EE, resulting in what is known as the EE gap. This gap can be explained by various factors, which can be grouped under the headings of market failures (including informational failures), behavioural failures and other factors as described in Chapter 1. Different policy instruments are designed to address these failures and promote the adoption of energy-efficient technologies. Considering the current context, implementing effective EE policies is crucial, so of course there is a need to understand these policy instruments and their effectiveness.

This dissertation reviews and analyses some of the policy instruments designed to overcome the EE gap at household level and some ways of enhancing its effectiveness. Chapter 1 provides a literature review based on the empirical evidence to date as an aid in understanding the aforementioned failures and the policy instruments designed to address them. Each EE policy is designed to overcome market or behavioural failures or other factors. Command and control instruments (codes and standards) establish how products should be produced in order to minimise energy consumption effectively, and price instruments are policies that directly affect product prices. They usually include taxes, subsidies and rebate programmes. These policies are designed to address market failures, and they are particularly relevant for the household sector. Rebate programmes seek mainly to promote the purchase of highly efficient products. However, these price instruments are not always successful in nudging consumers towards more energy-efficient products. Finally, informational instruments include energy labels, smart meters, information feedback tools and energy audits. These policies aim to provide consumers with additional information, and they are usually designed to overcome informational and behavioural failures.

Energy labels are used on almost all energy-using durable goods in the household sector. They seem to be one of the most widely applied EE policies for overcoming informational barriers. Consumers are usually willing to pay a price premium for products that carry labels of this type. It is also important to note that awareness and understanding of EE labels varies from one sector, product category and country to another.

The effectiveness of EE labels in promoting purchases of energy-efficient products has sometimes been called into question. One reason is that consumers may have difficulties in fully understanding the energy consumption information provided on labels (in kWh/year) (de Ayala et al., 2020; de Ayala and Solà, 2022). Some authors argue that a useful way of overcoming this barrier is to convert energy consumption information into monetary information (Kallbekken et al., 2013; Stadelmann and Schubert, 2018).

- Is providing *monetary information* an effective way of increasing the adoption of energy-efficient appliances? Evidence from field experiments

Chapters 2 and 3 of this dissertation analyse how providing energy consumption information on appliances in monetary terms (in different formats) affects consumer decision-making. Two field experiments were designed and executed to enhance understanding of this point: one focussed on providing information in terms of costs and the other in terms of savings. The idea was to test whether the effect on consumers was different when the information provided focussed on one area or the other.

Specifically, Chapter 2 seeks to test whether providing monetary information on ***lifetime energy savings*** (LES) in household appliances can significantly increase purchases of energy-efficient appliances. To that end, a field experiment with small retailers was run in 2018. The appliances studied were fridges, washing-machines and dishwashers, as they account respectively for 30.6%, 11.8% and 6.12% of energy consumption at Spanish households. The impact of monetary information on actual purchases of appliances was tested in different ways: (i) by including a monetary label to display energy savings over the lifetime of the product; (ii) via monetary information provided by sales staff; and (iii) by a combination of (i) and (ii). The effectiveness of providing monetary information was found to depend on the appliance and on the specific way in which information was provided. More precisely, for washing machines monetary information provided via a monetary label seems effective while for fridges both monetary information provided by sales staff and the combination of a monetary label and information from sales staff seem to be effective. Surprisingly, no effect is found for dishwashers.

Chapter 3 supplements that analysis by looking at how providing monetary information on **lifetime energy cost** (LEC) affects purchases of energy-efficient appliances. In this case, the field experiment was carried out at a major Spanish retailer (El Corte Inglés). The appliances studied were washing-machines, fridges, dishwashers and tumble-driers. Monetary information was provided in two different ways: (i) directly by sales staff; and (ii) both directly by sales staff and via a supplementary label. It was found that providing monetary information on LEC is not always an effective way of increasing purchases of more energy-efficient appliances, and that the degree of effectiveness differs different depending on both the appliance and the specific way in which information is provided. Monetary LEC information provided by sales staff alone is effective in promoting purchases of class A^{++} washing-machines, fridges and dishwashers but no effect is found for tumble-driers. This information from sales staff plus a supplementary label is effective in increasing purchases of A^{++} washing-machines and dishwashers and A^{+++} tumble-driers, but no effect is found for fridges.

Table 22 provides a visual summary of the effectiveness on LEC and LES monetary information as tested in Chapters 2 and 3. As it can be observed, our findings suggest that there is no clear consensus on the effectiveness of monetary information as the literature points out. Some of the evidence shows that monetary information could be effective (Allcott and Sweeney, 2016; Blasch et al., 2022; Bull, 2012; Deutsch, 2010; Heinzle, 2012) but some indicates that it may depend on the product category (Kallbekken et al., 2013; Stadelmann and Schubert, 2018), may have no effect at all (Carroll et al., 2016b; Skourtos et al., 2021) or may even have a negative effect (d'Adda et al., 2022). So, there are no clear answers as to the effectiveness of monetary information apart from the finding that the policy is highly sensitive to design features such as the products for which is used, consumer idiosyncrasy, etc.

In conclusion, based on the evidence shown in this dissertation it can be argued that monetary information may be useful for increasing the adoption of energy-efficient appliances, but just how effective it is, depends on the form of the information (lifetime energy savings or lifetime energy costs), on the appliance considered (washing machines, fridges, dishwashers or tumble-driers) and on other factors.

Even if monetary LES information gives better results than monetary LEC information, the challenges that may be posed by implementing a monetary label with LES information must be considered. Estimating savings requires a benchmark (the benchmark considered in Chapter 2 is the maximum energy consumption for each product category), which may change from time to time. A label with such information would not be very feasible from a policy point of view as it would have to be regularly updated. However, a monetary label based on cost may be easier to implement.

One of the challenges faced by European monetary labels is how to apply them in the different countries of the EU, given that different countries may have different energy prices. One practical suggestion may be for EE labels to include a QR code. This code can link to energy costs over the lifetime of each appliance based on the average electricity price in each particular country.

Table 22: Summary of field experiment results

		Appliances			
		Washing machine	**Fridge**	**Dishwasher**	**Tumble drier**
Field experiment 1: ✓ **Run at small retailers** ✓ **Start date: Feb 2018; End date: July 2018** ✓ **Monetary LES information (€)** ✓ **Three different treatments**	Treatment 1: supplementary label	✓	-	-	NA
	Treatment 2: sales staff	-	✓	-	NA
	Treatment 3: combination of sales staff and complementary label	-	✓	-	NA

		Washing machine		Fridge		Dishwasher		Tumble drier	
		A+++	Other	A+++	Other	A+++	Other	A+++	other
Field experiment 2: ✓ **Run at a big retailer (El Corte Inglés)** ✓ **Start date: August 2018;** ✓ **End date: December 2018** ✓ **Monetary LEC information (€)** ✓ **Two different treatments**	Treatment 1: sales staff	✗	✓	✗	✓	✗	✓	-	-
	Treatment 2: combination of sales staff and complementary label	✗	✓	-	-	✗	✓	✓	✗

Note:

- **✓means that this treatment increases the probability of purchasing an energy-efficient (A+++) appliance**
- **✗means that this treatment decreases the probability of buying an energy-efficient (A+++) appliance**
- **- means that this treatment is not statistically significant**
- **NA means that this appliance is not under study in this field experiment**

- Evidence on rebate programmes and the memory effect of the RENOVE programme: results from field and lab experiments

From the description in Chapter 3, it is known that a rebate programme was being run in some El Corte Inglés stores prior to the experiment. Such programmes are implemented by governments to subsidise the replacement of older products by new, more energy-efficient models.

The evidence on the effectiveness of rebate policies in increasing the purchase of energy-efficient appliances is not conclusive. Some studies show that the effect may be positive (Datta and Filippini, 2016) while others find that effectiveness depends on the product category (Chuang et al., 2018) and on other variables such as income, risk and time preferences (Galarraga et al., 2013; Houde and Aldy, 2017; Olsthoorn et al., 2017). Many studies have also shown that impact may be negative in terms of rebound effects or inefficiencies (Galarraga et al., 2013).

In the field experiment described in Chapter 3, we found an effect that we called the "RENOVE *memory effect":* in those places where a RENOVE programme was running before the experiment, its effect seemed to persist well after the end of the programme itself. This field experiment thus enabled us to analyse other effects (and co-benefits) of the RENOVE programme. The finding of the memory effect opens up a new space for discussion of the effectiveness of rebate programmes. So far, studies have focused only on analysing actual policy implementation periods. The fact that the RENOVE continues to have a positive effect beyond the end of the programme period itself raises the question of whether the same happens with other product categories or other policies.

In an attempt to better understand the memory effect, Chapter 4 reports tests and analyses to determine what factors may explain its existence. In this case, 166 subjects took part in a lab experiment where they had to choose between buying a high-efficiency fridge and a lower-efficiency fridge with the following information: energy prices (maximum and minimum), fridge lifetime, energy consumption and purchasing price. Subjects made these choices in 4 different scenarios labelled as Scenario 1, Scenario 2 (subjects knew how many tokens were left after paying for the chosen fridge and the LEC), Scenario 3 (subjects decided between fridges while a RENOVE rebate programme was running) and Scenario 4 (subjects chose between fridges after RENOVE had expired).

60.24% of the subjects bought a high-efficiency fridge in Scenario 2 and 89.75% in Scenario 3 (while the RENOVE programme was running). This increase in the purchase of high-efficiency fridges might indicate that the RENOVE helped to nudge consumers toward better options in terms of EE. 51.20% of the subjects bought highly efficient fridge in all the scenarios, while 13.25% showed the memory effect (they continued making the efficient choice after the RENOVE had expired). The memory effect reported in Chapter 3 is therefore ratified in the controlled environment of a lab experiment. Personal characteristics conducive to the existence of this effect were also identified. Rebate programmes have been called into question many times in the literature, but research has not considered the possibility that their effects may last outlast the programmes themselves. Why this memory effect should exist is not totally clear to us. The fact that rebate programmes are usually supplemented by information campaigns that highlight the benefits of investing in EE may be a reason. What seems clear is that the memory effect can be seen as a co-benefit of rebate schemes that has never been considered before in the literature.

The results reported in Chapters 3 and 4 have helped us to encompass and enrich the evidence on the effectiveness of rebate programmes, particularly RENOVE, and provided insights on how such programmes should be designed. The research undertaken for this thesis has revealed that: (i) for one segment of the population the RENOVE programme is effective, since there are consumers who go with the idea of buying an appliance and are nudged into investing in EE thanks to this programme; (ii) for another segment the programme is not effective, as they will invest in EE regardless of whether they receive economic aid from the RENOVE or not.

Currently one of the many barriers to EE investment for certain sectors of the population is the budget constraint. On average, A+++ appliances (especially dishwashers and refrigerators) are €250 more expensive than A++.

So how can RENOVE programs be *modified*? One interesting way is to channel financial support from the rebate programme to those consumers whose decisions may be swung by the programme. This could potentially be done through income tax returns by providing different levels of financial support for different income brackets. The proposal to modify the design of rebate programmes through tax returns one that should be tested to determine its effectiveness and efficiency.

The studies reported in this dissertation aims to shed light and identify several gaps and therefore openings for future research in the field of energy economics and behavioural economics. Chapters 2 and 3 identify the barriers to and challenges for the implementation of monetary information on EE labels. One of the main conclusions concerning the effectiveness of monetary information is that it depends on the product category, format and country. It would therefore be a good idea to test the effectiveness of a monetary energy label in different EU countries simultaneously (with the same monetary label format in all the countries) and in the same product category so as to obtain comparable results. Chapter 4 points out potential future research lines. It would be interesting to test how consumers react to rebate programmes on appliances and other products (e.g. vehicles) by considering the memory effect. Besides running a field experiment controlling for sales before, during and after rebate programmes could provide more insights into the memory effect in a natural environment.

Finally, it is important to highlight that according to the latest IPCC report (IPCC, 2022), keep investing in EE is crucial for climate change mitigation, so devoting efforts to this research line is particularly relevant. *The best energy is energy that is not consumed*.

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8 Annex - Chapter 1

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Abadie et al.	2012	Determinants of energy efficiency investments in the US	Energy efficiency; Energy assessments; Energy policies	Journal article	2011	Industry	.	USA	Data available; Net present value and real options
Abrahamse et al.	2005	A review of intervention studies aimed at household energy conservation	Review; Interventions; Household energy conservation	Journal article	.	Household	.	.	Review
Alberini and Towe	2015	Information v. Energy Efficiency Incentives: Evidence from Residential Electricity Consumption in Maryland	Energy Efficiency, Household Behaviour, Energy Efficiency Incentives, Electricity Usage, Home Energy Audit.	Journal article	2011-2012	Household	.	USA	Natural field experiment
Alberini et al.	2014	Does the Swiss Car Market Reward Fuel Efficient Cars? Evidence from Hedonic Pricing Regressions, Matching and a Regression Discontinuity Design	Fuel economy; CO2 emissions; Passenger vehicles; Hedonic pricing model; Matching Estimator; Regression Discontinuity Design; Fuel efficiency premium; Discounted future fuel costs.	Journal article	2010-2011	Household	Transport	Switzerland	Data available; Hedonic regression
Alborzi et al.	2017	Consumers' comprehension of the EU Energy label for washing machines	Energy efficiency, European consumers, washing machines, sustainability, revision	Journal article	2015	Household	Appliances	Europe (Czech Republic, Finland, France, Ger-many, Hungary, Italy, Poland, Romania, Spain, Sweden and the United Kingdom)	Survey
Alcott	2011	Consumers’ Perceptions and Misperceptions of Energy Costs	.	Journal article	2010	Household	Transport	USA	Survey
Allcott	2011	Consumers’ Perceptions and Misperceptions of Energy Costs	.	Journal article	2010	Household	Transport	USA	Survey
Allcott and Knittel	2019	Are consumers poorly-informed about fuel economy? Evidence from two experiments	Behavioural public economics, fuel economy standards, lab experiments, information provision.	Journal article	2014	Household	Transport	USA	Experiment
Allcott and Sweeney	2015	Can retailers inform consumers about energy costs? Evidence from a field experiment	Energy efficiency, energy-using durables, information disclosure, randomized field experiments.	Journal article	2012-2013	Household	Appliances	USA	Field experiment
Allcott and Taubinsky	2015	Evaluating Behaviourally Motivated Policy: Experimental Evidence from the Lightbulb Market	.	Journal article	.	Household	Appliances	USA	Field experiment

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Allcott and Wozny	2013	Gasoline Prices, Fuel Economy, and the Energy Paradox	.	Journal article	2008	Household	EE gap	USA	Survey
Amecke	2012	The impact of energy performance certificates: A survey of German home owners	Energy performance certificates (EPC); Energy efficiency; Buildings	Journal article	2009	Household	Property	Germany	Survey
Andor et al.	2020	Consumer inattention, heuristic thinking and the role of energy labels	Environmental certification; discrete choice experiment; energy efficiency; energy-using durables	Journal article	2015	Household	EE labels	Germany	Experiment
Aravena et al.	2016	Money, Comfort or Environment? Priorities and Determinants of Energy Efficiency Investments in Irish Households	Energy efficiency measures. Energy saving, Investments. Ireland, Motivations	Journal article	2006	Household	Property	Ireland	Modelling
Aroonruengsawat et al.	2012	The Impact of State Level Building Codes on Residential Electricity Consumption	Residential Electricity Consumption, Building Codes, Regulation	Journal article	1970-2006	Household	Property	USA	Modelling
Asensio and Delmas	2016	The dynamics of behaviour change: Evidence from energy conservation	Energy conservation; Decision framing; Repeated behaviour; Randomized controlled trials	Journal article	2011-2012	Household	Appliances	USA	Field experiment
Baginski and Weber	2017	A Consumer Decision-making Process? Unfolding Energy Efficiency Decisions of German Owner-occupiers	Energy efficient refurbishments; decision-making process; consumer purchase decision	Journal article	2016	Household	Property	Germany	In-depth interviews
Bailey et al.	2008	Factors which influence Nova Scotia farmers in implementing energy efficiency and renewable energy measures	Energy conservation; Energy efficiency; Renewable energy; Agriculture; Nova Scotia	Journal article	2004	Agriculture	.	Nova Scotia	Survey
Baldini et al.	2018	The impact of socioeconomic and behavioural factors for purchasing energy efficient household appliances: A case study for Denmark	Consumer behaviour; Energy efficiency; Household appliances; Purchase propensity; Regression model	Journal article	2012	Household	Appliances	Denmark	Survey
Bamberg et al.	2003	Choice of Travel Mode in the Theory of Planned Behaviour: The Roles of Past Behaviour, Habit, and Reasoned Action	Energy conservation; Energy efficiency; Renewable energy; Agriculture; Nova Scotia	Journal article	1994-1995	Service	Transport	Germany	Survey
Banerjee and Salomon	2003	Eco-labelling for energy efficiency and sustainability: a meta-evaluation of US programs	Environmental labelling; Green power; Electricity marketing	Journal article	1979-2001	Household, Services	Appliances, Office equipment	USA	Meta-evaluation of US policies

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Banfi et al.	2008	Willingness to pay for energy-saving measures in residential buildings	Energy efficiency; Energy saving; Choice experiment; Conjoint analysis; Discrete choice; Housing; Fixed effect logit	Journal article	2003	Household	Appliances	Switzerland	Survey
Bastida et al.	2019	Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming	Energy efficiency; Demand response; CO2 emissions; Smart meters; Electricity	Journal article	2019	Household	Appliances	Europe	Modelling
Berrang-Ford et al.	2015	Systematic review approaches for climate change adaptation research	Climate change; Systematic review; Human dimensions of climate change; Vulnerability; Adaptation; Research synthesis; Social sciences; Realist review	Journal article	.	.	.	.	Systematic review
Bird and Hernandez	2012	Policy options for the split incentive: Increasing energy efficiency for low-income renters	Split incentive; Energy poverty; Energy efficiency	Journal article	.	Household	.	USA	Evaluation of policies
Blancard and Martin	2014	Energy efficiency measurement in agriculture with imprecise energy content information	Data Envelopment Analysis; Energy efficiency; Uncertainty	Journal article	2007	Agriculture	.	France	Data Envelopment Analysis approach
Blasch et al.	2019	Boundedly rational consumers, energy and investment literacy, and the display of information on household appliances	Energy-efficiency; Bounded rationality; Energy-using durables; Information; Energy label; Energy literacy; Choice experiment	Journal article	2015	Household	Appliances	Switzerland	Choice experiment
Blumstein	2010	Program evaluation and incentives for administrators of energy-efficiency programs: Can evaluation solve the principal agent problem?	Energy-efficiency; Incentives; Principal/agent	Journal article	.	.	.	USA	.
Boardmand et al.	2000	Choosing Cleaner Cars: The Role of Labels and Guides - Executive Summary of The Final Report on Vehicle Environmental Rating Schemes	.	Journal article	.	Household	Transport	UK	Review
Bonde et al.	2013	Is energy performance capitalized in office building appraisals?	EPC; Energy Performance Certificate; Capital value; Hedonic price model; Office buildings; Sweden	Journal article	2003-2010	Household	Property	Sweden	Econometric model
Boomhower and Davis	2014		Energy efficiency; Regression discontinuity; Additionality	Journal article	2009-2012	Household	Appliances	Mexico	Regression discontinuity

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Borozan et al.	2018	Regional-level household energy consumption determinants: The European perspective	Energy consumption; Households; EU regions; Panel analysis	Journal article	2005-2013	Household	.	Europe	Modelling
Bresson et al.	2004	Economic and structural determinants of the demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators	.	Journal article	1975-1995	Service	Transport	France	Panel data; Fixed effects
Brounen and Kok	2011	Economic and structural determinants of the demand for public transport: an analysis on a panel of French urban areas using shrinkage estimators	Energy efficiency; Housing market; Energy labels; Environmentalism	Journal article	2008-2009	Household	Property	Netherlands	Logit
Bull	2012	Loads of green washing—can behavioural economics increase willingness -to-pay for efficient washing machines in the UK?	Household appliances; Energy efficiency; Behavioural economics	Journal article	2011	Household	Appliances	UK	Hypothetical purchase via survey
Busse et al.	2013	Are Consumers Myopic? Evidence from New and Used Car Purchases	.	Journal article	2012	Household	Transport	USA	Econometric model
Bye and Bruvoll	2008	Multiple instruments to change energy behaviour: The emperor's new clothes?	Energy instruments; Taxes; Subsidies; Green certificates; White certificates; Carbon taxes	Journal article	.	.	.	.	Evaluation of policies
Cagno and Trianni	2012	Exploring drivers for energy efficiency within small- and medium-sized enterprises: First evidences from Italian manufacturing enterprises	Industrial energy efficiency; Drivers; Small and medium-sized enterprises	Journal article	.	Industry	.	Italy	Econometric model
Cajias and Piazolo	2013	Green Performs Better: Energy Efficiency and Financial Return on Buildings	Germany; Housing; Residential property; Energy consumption; Energy performance certificates; Energy efficiency; Sustainability; Quantile regression; Portfolio estimation	Journal article	2008-2010	Household	Energy consumption	Germany	Regression analysis
Carroll et al.	2016	The Effects of Energy Cost Labelling on Appliance Purchasing Decisions: Trial Results from Ireland	Energy efficiency; Household appliances; Energy cost labelling; Retail experiment	Journal article	2013	Household	Appliances	Ireland	Field experiment

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Carroll et al.	2016	Low energy efficiency in rental properties: Asymmetric information or low willingness-to-pay?	Energy efficiency valuation; Rental markets; Choice experiment; Building energy rating	Journal article	2014	Household	Property	Ireland	DCE
Carroll et al.	2014	Reducing household electricity demand through smart metering: The role of improved information about energy saving	Residential electricity demand; Smart meters; Consumption feedback; Household knowledge; Conservation motivations	Journal article	2009-2010	Household	Appliances	Ireland	Randomised control experiment
Casado et al.	2017	Energy efficiency in households: The effectiveness of different types of messages in advertising campaigns	Energy efficiency; Behavioural guidelines; Economic benefit; Degree of informational persuasion; Future behavioural intention	Journal article	2014	Household	.	Spain	Experiment
Cattaneo	2019	Internal and external barriers to energy efficiency: which role for policy interventions?	Energy efficiency gap; Energy policy; Behavioural economics	Journal article	.	Household	.	.	Literature review
Chegut et al.	2014	Supply, Demand and the Value of Green Buildings	.	Journal article	1999-2009	Household	Property	UK	Hedonic model
Chegut et al.	2016	Energy efficiency and economic value in affordable housing	Affordable housing; Energy efficiency; Energy performance certificates	Journal article	2008-2013	Household	Property	Netherlands	Hedonic real estate valuation
Chou and Ngo	2016	Smart grid data analytics framework for increasing energy savings in residential buildings	Smart grid; Big data; Optimization; Time series data analytics; Energy saving; Home appliance; Web-based portal	Journal article	.	Household	.	Taiwan	Modelling
Codagnone et al.	2016	Labels as nudges? An experimental study of car eco-labels	Eco-label; Nudge; Willingness to pay; Fuel economy; Experiments; CO2 emission	Journal article	2012-2013	Household	Transport	UK	Lab experiment
Cohen et al.	2017	Consumer myopia, imperfect competition and the energy efficiency gap: Evidence from the UK refrigerator market	Energy efficiency; Electricity prices; Consumer myopia; Imperfect competition	Journal article	2002-2007	Household	Appliances	UK	Demand Supply
Collins and Curtis	2018	Willingness-to-pay and free-riding in a national energy efficiency retrofit grant scheme	Willingness to pay; Free-riders; Energy efficiency; Retrofit	Journal article	2009	Household	Property	Ireland	Hedonics
Dale and Fujita	2008	An Analysis of the Price Elasticity of Demand for Household Appliances	.	Journal article	1980-2002	Household	Appliances	USA	Elasticities

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Das and Wiley	2014	Determinants of premia for energy-efficient design in the office market	.	Journal article	2004-2011	Service	Property	USA	Hedonic model
Das et al.	2011	Dynamics of Green Rentals over Market Cycles: Evidence from Commercial Office Properties in San Francisco and Washington DC	.	Journal article	2007-2010	Service	Property	USA	Hedonic model
Datta and Filippini	2016	Analysing the impact of ENERGY STAR rebate policies in the US	Residential appliances; ENERGY STAR · Rebate policies; Difference-in-differences; Nonlinear methods	Journal article	2005-2007	Household	Appliances	USA	Difference in Difference
Datta and Gulati	2011	Utility rebates for ENERGY STAR appliances: Are they effective?	Eco-labelling; Energy efficiency; Appliances; Utility rebates; Carbon saving; Energy saving	Journal article	2001-2006	Household	Appliances	USA	Regression analysis
Davis	2011	Evaluating the Slow Adoption of Energy Efficient Investments: Are Renters Less Likely to Have Energy Efficient Appliances?	Landlord-Tenant Problem; Energy Efficiency; Efficiency Gap;	Editorial	2005	Household	Appliances	USA	Survey
Davis	2008	Durable goods and residential demand for energy and water: evidence from a field trial	.	Journal article	1997	Household	Appliances	USA	Field experiment
Davis and Metcalf	2016	Does Better Information Lead to Better Choices? Evidence from Energy-Efficiency Labels	Energy-Efficiency; Inattention; Information Provision; Energy Demand; Energy Guide	Journal article	2014	Household	Appliances	USA	Choice experiment
de Ayala et al.	2016	The price of energy efficiency in the Spanish housing market	Energy; Housing; Energy performance certification; Spain; Hedonic pricing	Journal article	2013	Household	Property	Spain	Hedonic model
de Miguel et al.	2017	Informing the Transitions towards Low-carbon Societies	.	Editorial	.	.	Failures	.	Review
DECC	2014	Evaluation of the DECC and John Lewis energy labelling trial	.	Report	2013-2014	Household	Appliances	UK	Field experiment
del Rio	2010	Analysing the interactions between renewable energy promotion and energy efficiency support schemes: The impact of different instruments and design elements	Energy efficiency; Renewable energy; Interactions	Journal article	.	.	.	.	Evaluation of policies

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DellaVigna	2009	Psychology and Economics: Evidence from the Field	.	Journal article	.	Household	.	.	Theory
Deutsch	2010	Life Cycle Cost Disclosure, Consumer Behaviour, and Business Implications	Decision-making; Eco-labelling; Energy efficiency; Household appliances; Industrial ecology; Sustainable consumption	Journal article	2006	Household	Appliances	Germany	Choice experiment
Dieu-Hang et al.	2017	Household adoption of energy and water-efficient appliances: an analysis of attitudes, labelling and complementary green behaviours in selected OECD countries	Energy conservation; Water conservation; Eco-labelling scheme; Energy efficiency; Water efficiency	Journal article	2011	Household	Appliances	OECD countries	Multivariate probit model
Drivas et al.	2019	The effect of house energy efficiency programs on the extensive and intensive margin of lower-income households' investment behaviour	Energy efficiency retrofits; Subsidy; Exogenous change; Extensive and intensive margin; Household investment	Journal article	2011-2015	Household	Property	Greece	Econometric model
Dumortier et al.	2015	Effects of providing total cost of ownership information on consumers' intent to purchase a hybrid or plug-in electric vehicle	Rank-ordered logit; Life cycle cost; Label information; Battery electric vehicles	Journal article	2013	Household	Transport	USA	Survey
Eicholtz et al.	2013	The Economics of Green Building	.	Journal article	2007-2009	Service	Property	USA	Data available; Hedonic model
Eicholtz et al.	2010	Doing Well by Doing Good? Green Office Buildings	.	Journal article	2004-2007	Service	Property	USA	Data available; Hedonic model
Falk et al.	2016	The preference survey module: a validated instrument for measuring risk. Time and social preferences	Survey validation; Experiment; Preference measurement	Journal article	2010-2011	Household	.	Germany	Choice experiment
Farsi	2010	Risk aversion and willingness to pay for energy efficient systems in rental apartments	Energy efficiency; Risk aversion; Choice experiment	Journal article	2003	Household	Property	USA	Experiment
Faruqui et al.	2010	The impact of informational feedback on energy consumption—A survey of the experimental evidence	Energy efficiency; Energy conservation; Information; Feedback; In-home displays	Journal article	.	Household	.	Comparative	Survey
Filippidau et al.	2017	Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing	Energy efficiency; Renovation rate;	Journal article	2010-2014	Household	.	Netherlands	Statistic

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		the national energy labelling database	Monitoring; Housing; Big data; The Netherlands						
Fleiter et al.	2012	Adoption of energy-efficiency measures in SMEs — An empirical analysis based on energy audit data from Germany	Energy-efficiency in SMEs; Adoption of energy-efficiency measures; Barriers to energy-efficiency	Journal article	2008-2010	Industry	.	Germany	Survey
Franke et al.	2012	Enhancing sustainability of electric vehicles: A field study approach to understanding user acceptance and behaviour	.	Journal article	.	Household	Transport	Germany	Field experiment
Fraunhofer ISI	2019	Pioneering research on 2050 energy savings potentials | The Coalition for Energy Savings	.	Report	.	.	.	Europe	.
Frederiks et al.	2015	Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour	Behavioural economics; Psychology; Energy consumption; Energy conservation; Household energy use; Behaviour change	Journal article	.	Household	.	Theory	Review
Frondel and Vance	2013	Heterogeneity in the Effect of Home Energy Audits: Theory and Evidence	Energy audit; Environmental policy; Mixed logit; Random-coefficient models	Journal article	2007	Household	.	Germany	Mixed logit
Fuerst and McAllister	2011b	Green Noise or Green Value? Measuring the Effects of Environmental Certification on Office Property Values	.	Report	.	Household	Property	USA	Data available; Hedonic model
Fuerst and McAllister	2011a	The impact of Energy Performance Certificates on the rental and capital values of commercial property assets	Energy Performance Certificates; Commercial property values; Real estate appraisal	Journal article	2011	Household	Property	UK	Data available; Hedonic model
Fuerst et al.	2016	Energy performance ratings and house prices in Wales: An empirical study	Energy performance certificate; Dwellings; Prices; Wales	Journal article	2003-2014	Household	Property	Wales	WTP
Fuerst et al.	2013	Is intrinsic energy efficiency reflected in the pricing of office leases?	Commercial offices; Eco-labelling; Energy efficiency; Energy Performance Certificate; Hedonic modelling; Rental premium; Rental values	Journal article	2006-2010	Service	Property	UK	Data available; Hedonic model
Fuerst et al.	2015	Does energy efficiency matter to home-buyers? An investigation of EPC ratings and transaction prices in England	Energy efficiency; House price; Hedonic model; Repeat sales model	Journal article	1995-2012	Household	Property	England	Data availble; Hedonic model

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Gabe and Rohm	2016	Do tenants pay energy efficiency rent premiums?	Sustainability; Climate change; Social responsibility; Energy; Office; NABERS	Journal article	.	Service	Property	Australia	Data available; Hedonic model
Galarraga and Markandya	2003	The Analysis of the Welfare Effects of an Environmental Product Tax: An Application to the Taxation of Car Tyres in Hungary	.	Journal article	1996-1997	Household	Transport	Hungary	Data available; AIDS model
Galarraga et al.	2013	Efficiency, effectiveness and implementation feasibility of energy efficiency rebates: The “Renove” plan in Spain	Energy efficiency; Spain; Rebates; Appliances; Rebound effect	Journal article	2008-2009	Household	Appliances	Spain	Dead Weight Loss estimation
Galarraga et al.	2016	Designing incentive schemes for promoting energy-efficient appliances: A new methodology and a case study for Spain	Energy efficiency; Taxes; Subsidies; Bonus-malus; Spain; Appliances	Journal article	2012	Household	Appliances	Spain	Dead Weight Loss estimation
Galarraga et al.	2011a	Price premium for high-efficiency refrigerators and calculation of price-elasticities for close-substitutes: a methodology using hedonic pricing and demand systems	Demand systems; Hedonic method; Energy efficiency labelling; Household appliances (dishwashers)	Journal article	2009	Household	Appliances	Spain	Regression analysis
Galarraga et al.	2011b	Willingness to pay and price elasticities of demand for energy-efficient appliances: Combining the hedonic approach and demand systems	Demand systems; Hedonic pricing; Energy efficiency labelling; Household appliances (refrigerators)	Journal article	2009	Household	Appliances	Spain	Regression analysis
Galarraga et al.	2014	The price of energy efficiency in the Spanish car market	Spain; Transport; Energy Efficiency; Hedonic methods	Journal article	2012	Household	Transport	Spain	Data available; Hedonic model
Galarraga et al.	2012	Evaluación económica del etiquetado de eficiencia energética: el caso de las lavadoras en España	energy efficiency, household appliances, hedonic pricing, demand system.	Journal article	2009	Household	Appliances	Spain	Hedonic regression
Galvin	2010	Thermal upgrades of existing homes in Germany: The building code, subsidies, and economic efficiency	Thermal refits; Climate change mitigation; German CO2 policy; Energy efficiency	Journal article	.	Household	Property	Germany	.
Gans et al.	2013	Smart meter devices and the effect of feedback on residential electricity consumption: Evidence from a natural experiment in Northern Ireland	Residential energy; Electricity demand; Feedback; Smart meter; Information	Journal article	1990-2009	Household	Appliances	Northern Ireland	Field experiment

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Gerarden et al.	2017	Assessing the Energy-Efficiency Gap	.	Journal article	.	Household	EE gap	.	Review
Gibbons and Gwin	2004	History of conservation measures for energy	.	Book chapter	.	Household	.	Theory	.
Gigerenzer and Gaissmaier	2011	Heuristic decision-making	Accuracy-effort trade-off; Business decisions; Ecological rationality; Legal decision-making; Medical decision-making; Social intelligence	Journal article	.	Household	.	Theory	.
Gillingham and Palmer	2014	Bridging the Energy Efficiency Gap: Policy Insights from Economic Theory and Empirical Evidence	.	Journal article	.	.	.	.	Literature review
Gillingham et al.	2009	Energy Efficiency Economics and Policy	.	Journal article	.	Household	.	Theory	.
Gillingham et al.	2006	ENERGY EFFICIENCY POLICIES: A Retrospective Examination	Appliance standards; Demand-side management; Incentives; Information; Voluntary programs	Journal article	.	.	.	.	Literature review
Girod	2017	How do policies for efficient energy use in the household sector induce energy-efficiency innovation? An evaluation of European countries	Policy evaluation; Energy efficiency; Technological change; Demand-pull	Journal article	1980–2009	.	.	European countries	Econometric model
Gölz	2017	Does feedback usage lead to electricity savings? Analysis of goals for usage, feedback seeking, and consumption behaviour	Feedback; Electricity saving; Rubicon model; Feedback intervention theory; Smart metering	Journal article	2010	Household	Appliances	Germany, Austria	Experiment
Götz and Tholen	2016	Stock Model Based Bottom-up Accounting for Washing Machines: Worldwide Energy, Water and Greenhouse Gas Saving Potentials 2010–2030	.	Journal article	2010-2030	Household	Appliances	Comparative	Model
Greene	2011	Uncertainty, loss aversion, and markets for energy efficiency	Energy efficiency; Fuel economy; Loss aversion	Journal article	2004	Household	Transport	USA	Montecarlo
Greene	2010	How Consumers value Fuel Economy: a literature review	.	Report	.	Household	Transport	USA	.

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Greene et al.	2009	Fuel Economy: The Case for Market Failure	.	Book	.	Household	Transport	.	Review
Greene et al.	2005	Feebates, rebates and gas-guzzler taxes: A study of incentives for increased fuel economy	Feebates; Fuel economy; Automobile policy	Journal article	2000	Household	Transport	USA	Evaluation of policies
Hahn et al.	2007	The Impact of Behavioural Science Experiments on Energy Policy	Energy policy; Behavioural science; Energy consumption	Journal article	2004	Household	Transport	Switzerland	Survey
Halvorsen and Larsen	2001	The flexibility of household electricity demand over time	Residential electricity consumption; Household production; Dynamic analysis; Micro data	Journal article	1975-1994	Household	Appliances	Norway	Survey
Haq and Weiss	2016	CO2 labelling of passenger cars in Europe: Status, challenges, and future prospects	Passenger cars; Car labelling; CO2 emissions; Fuel consumption; Energy label; Sustainable transport	Journal article	1999-2015	Household	Transport	EU	Review
Hardisty et al.	2017	Encouraging energy efficiency: product labels activate temporal trade-offs.	.	Journal article	2016	Household	Appliances	Canada	Experiment
Harrington	2017	Quantifying energy savings from replacement of old refrigerators	Refrigerators; Efficiency; End use energy; Retrofit	Journal article	2013	Household	Appliances	Australia	Experiment
Heinzle and Wüstenhagen	2012	Dynamic Adjustment of Eco-labelling Schemes and Consumer Choice – the Revision of the EU Energy Label as a Missed Opportunity?	Energy labelling; Environmental policy; Sustainable consumption; Choice-based conjoint experiment; Eco-innovation	Journal article	2009	Household	Appliances	Germany	Field experiment
Heres et al.	2017	The Role of Budgetary Information in the Preference for Externality-Correcting Subsidies over Taxes: A Lab Experiment on Public Support	Effectiveness; Lab experiment; Pigouvian taxes; Public policy; Public support; Revenues; Subsidies	Journal article	2012	Household	Fictitious good	Spain	Lab experiment
Hertel and Menrad	2016	Adoption of energy-efficient technologies in German SMEs of the horticultural sector—the moderating role of personal and social factors	Innovation; SME; Investment behaviour; Energy-efficiency gap; Intention–behaviour gap; TRA; Horticulture	Journal article	2011	Agriculture	.	Germany	Survey
Hille et al.	2016	Best in Class or Simply the Best? The Impact of Absolute Versus Relative Ecolabeling Approaches	Choice architecture; Ecolabeling; Passenger cars; Environmental policy; Consumer information	Journal article	.	Household	Transport	Europe	Survey

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Hinchliffe and Akkerman	2017	Assessing the review process of EU Eco-design regulations	Eco-design; Energy Labelling; Product policy; Resource efficiency; Review; Energy efficiency	Journal article	.	Household	EE labels	Europe	Review
Holland et al.	2016	Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors	.	Journal article	2011, 2014	Household	Transport	USA	Discrete choice experiment
Houde	2012	How Consumers Respond to Product Certification: A Welfare Analysis of the Energy Star Program	Quality disclosure; Certification; Attention allocation; Demand estimation	Journal article	.	Household	Appliances	USA	Modelling
Houde and Aldy	2017	Consumers' Response to State Energy Efficient Appliance Rebate Programs†	Subsidies; Energy Efficiency; ENERGY STAR; Stimulus	Journal article	2009	Household	Appliances	USA	Econometric model
Hrovatin et al.	2016	Factors impacting investments in energy efficiency and clean technologies: empirical evidence from Slovenian manufacturing firms	Energy efficiency gap; Energy efficiency investments; Clean technology investments; Drivers; Barriers; Manufacturing industries	Journal article	2005-2011	Industry	.	Slovenia	Data available; Econometric model
Hyland et al.	2013	The value of domestic building energy efficiency — evidence from Ireland	Domestic building energy ratings; Hedonic valuation; Ireland	Journal article	2008-2012	Household	Property	Ireland	Data available; Hedonic model
Jacobsen and Kotchen	2011	ARE BUILDING CODES EFFECTIVE AT SAVING ENERGY? EVIDENCE FROM RESIDENTIAL BILLING DATA IN FLORIDA	.	Journal article	2001-2002	Household	Property	USA	Difference in Difference
Jaffe et al.	2004	Economics of energy efficiency.	.	Book	.	Household	.	.	.
Jakob	2006	Marginal costs and co-benefits of energy efficiency investments: the case of the Swiss residential sector	Marginal costs; Energy efficiency; Co-benefits	Journal article	2003	Household	Property	Switzerland	Survey; Cost-Benefit analysis
Jareemit and Limmeechockai	2017	Understanding resident's perception on energy saving habits in households in Bangkok	Eco-design; Energy Labelling; Product policy; Resource efficiency; Review; Energy efficiency	Journal article	.	Household	.	Europe	Review
Jensen et al.	2016	Market response to the public display of energy performance rating at property sales	Energy label; Energy performance certificate; Energy performance rating; Real estate prices; Energy label advertisement	Journal article	2007-2011	Household	Property	Denmark	Data available; Regression

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Jensen et al.	2014	A long panel survey to elicit variation in preferences and attitudes in the choice of electric vehicles	Electric vehicles; Before and after experience; Stated preference; Long panel data	Journal article	.	Household	Transport	Denmark	Survey; State choice Experiment
Jimenez et al.	2016	Evaluation of subsidies programs to sell green cars: Impact on prices, quantities and efficiency	Subsidies; Automobile sector; Difference-in-difference estimator; Green policies	Journal article	2007-2010	Household	Transport	Spain	Difference in Difference
Johansson	2014	Improved energy efficiency within the Swedish steel industry—the importance of energy management and networking	Energy efficiency; Energy management; Networking; Iron and steel industry; Interviews	Journal article	2012	Industry	.	Sweden	Qualitative method- In deep interviews
Johnson	2006	Feebates: An effective regulatory instrument for cost-constrained environmental policy -	Feebates; Refunded emission payments	Journal article	.	.	Transport	Sweden	.
Jokiniewi et al.	2010	Energy consumption in agriculture transportation operations	Agriculture; Transportation; Tractor; Truck; Energy efficiency; Fuel consumption intensity; CAN-bus	Journal article	.	Agriculture	.	Finland	Estimation
Jones and Lomas	2015	Determinants of high electrical energy demand in UK homes: Socio-economic and dwelling characteristics	Electricity consumption; Socio-economic factors; Dwelling factors; Domestic buildings; Odds ratio	Journal article	2009-2010	Household	Energy consumption	UK	Survey
Jones et al.	2015	The socio-economic, dwelling and appliance related factors affecting electricity consumption in domestic buildings	Domestic electricity consumption; Domestic buildings; Socio-economic factors; Dwelling factors; Appliance factors	Journal article	.	Household	Appliances	.	Review
Kaklamanou et al.	2015	Using Public Transport Can Make Up for Flying Abroad on Holiday: Compensatory Green Beliefs and Environmentally Significant Behaviour	Compensatory beliefs; Conservation; Environmental attitudes; Energy; Environment; Ecological behaviour	Journal article	.	Service	Transport	UK	Survey; Regression
Kallbekken et al.	2013	Bridging the Energy Efficiency Gap: A Field Experiment on Lifetime Energy Costs and Household Appliances	Energy efficiency; Field experiment; Cost disclosure; Household appliances	Journal article	2009	Household	Appliances	Norway	Field experiment
Khanna et al.	2016	Effects of demand side management on Chinese household electricity consumption: Empirical findings from Chinese household survey	Residential electricity demand management; Tiered pricing; China Energy Label; Information feedback	Journal article	2012	Household	Appliances	China	Survey

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Knobloch et al.	2017	Simulating the deep decarbonisation of residential heating for limiting global warming to 1.5C	Technology Diffusion; Low-Carbon Heating; 1.5°C Target; Behavioural Modelling	Journal article	.	Household	CO_2 emissions	World	Non-equilibrium bottom-up model
Kok and Jennen	2012	The impact of energy labels and accessibility on office rents	Energy efficiency; Commercial real estate; Valuation	Journal article	2005-2010	Service	Property	Netherlands	Data available; Hedonic model
Kurani and Turrentine	2004	Automobile Buyer Decisions about Fuel Economy and Fuel Efficiency	.	Journal article	2003	Household	Transport	USA	Qualitative method- In deep interviews
Labandeira et al.	2012	Estimation of elasticity price of electricity with incomplete information	Electricity demand; Microeconometrics; Panel data.	Journal article	2006-2007	Household	Energy consumption	Spain	Model
Labandeira et al.	2005	A Residential Energy Demand System for Spain	.	Journal article	1973-1995	Household	Energy consumption	Spain	Model
Lang	2004	Progress in energy-efficiency standards for residential buildings in China	Energy-efficiency design standards; Residential buildings; Heating payment reform	Journal article	.	Household	Buildings	China	Review
Lillemo	2014	Measuring the effect of procrastination and environmental awareness on households' energy-saving behaviours: An empirical approach	Behavioural economics; Energy-saving behaviour; Procrastination	Journal article	2010	Household	Appliances	Norway	Survey
Linares and Labandeira	2010	Energy Efficiency: Economics and Policy	Energy; Energy efficiency; Environment; Public policy	Journal article	.	Household	.	.	Review
Liu et al.	2016	Using social norm to promote energy conservation in a public building	Social norms; Energy conservation; Petition Public building	Journal article	2010	Household	Appliances	USA	Field experiment
Long et al.	2018	Characteristics or culture? Determinants of household energy use behaviour in Germany and the USA	Energy use; Household behaviour; Oaxaca-Blinder decomposition; Germany; United States	Journal article	2013	Household	Energy consumption	Germany, USA	Regression analysis
Lucas and Galarraga	2015	Green Energy Labelling	Energy Efficiency; Spain; Labels; Appliances	Journal article	2012	Household	EE labels	Spain	QBDS
Manhoudt et al.	2002	Environmental labelling in The Netherlands: a framework for integrated farming	Integrated agriculture; Arable farming; Environmental labelling; Environment; Nutrient use; Pesticide use; Biodiversity.	Journal article	.	Agriculture	.	Netherlands	Comparative study

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Markandya et al.	2009	Analysis of tax incentives for energy-efficient durables in the EU	Tax incentives; Energy efficiency; Durables	Journal article	.	Household	Appliances	Europe	Regression analysis
Markandya et al.	2015	Policy instruments to foster energy efficiency	.	Book chapter	.	.	.	Europe	Evaluation of policies
Markandya et al.	2009	Analysis of tax incentives for energy-efficient durables in the EU	Tax incentives; Energy efficiency; Durables	Journal article	2007	Household	Appliances	Europe	Evaluation of policies
Maruejols and Young	2011	Split incentives and energy efficiency in Canadian multi-family dwellings	Energy efficiency; Agency effects; Household behaviour	Journal article	2003	Household	Property	Canada	Econometric model
Michelsen and Madlener	2016	Switching from fossil fuel to renewables in residential heating systems: An empirical study of homeowners' decisions in Germany	Residential heating systems, Private households, Technology replacement, Adoption barriers, Consumer choice	Journal article	2009-2010	Household	Appliances	Germany	Regression analysis
Min et al.	2014	Labelling energy cost on light bulbs lowers implicit discount rates	Energy efficient lighting; Implicit discount rate; Consumer preference; Choice experiment; Discrete choice analysis; Conjoint analysis	Journal article	.	Household	Appliances	USA	Experiment
Mueller and De Hann	2009	How much do incentives affect car purchase? Agent-based microsimulation of consumer choice of new cars—Part I: Model structure, simulation of bounded rationality, and model validation	Consumer behaviour; Policy analysis; Energy-efficient cars	Journal article	2005	Household	Transport	Switzerland	Survey
Murphy	2014	The influence of the Energy Performance Certificate: The Dutch case	Energy Performance Certificate; Existing dwellings; Instruments	Journal article	2008-2011	Household	Property	Netherlands	Survey
Nadel	2002	Appliance and Equipment Efficiency Standards	Regulations; Mandatory standards; U.S. standards; International standards	Journal article	.	Household	Appliances	Europe	Evaluation of policies
Nehler and Rasmusen	2015	How do firms consider non-energy benefits? Empirical findings on energy-efficiency investments in Swedish industry	Energy efficiency; Investments; Non-energy benefits; Explorative study; Investment decisions	Journal article	2013-2014	Industry	.	Sweden	Qualitative method- In deep interviews
Neij et al.	2009	Choice decision determinants for (non) adoption of EE technologies in households	Technology choice determinants; Discount rates; Energy efficiency; Household sector	Journal article	.	Household	Appliances	.	Review

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Newell and Siikamäki	2013	Nudging Energy Efficiency Behaviour: The Role of Information Labels	.	Journal article	.	Household	Appliances	USA	Lab experiment
Newell et al.	2014	Assessing energy rating premiums in the performance of green office buildings in Australia	Sustainability; Green office buildings; Green premiums; Green Star; NABERS energy rating; Non-green discounts	Journal article	.	Service	Property	Australia	Data available; Hedonic model
Noailly	2012	Improving the energy efficiency of buildings: The impact of environmental policy on technological innovation	Innovation; Technological change; Patents; Energy-efficiency; Buildings; Environmental policy	Journal article	1989–2004	Household	Property	Europe	Evaluation of policies
Noblet et al.	2006	Factors affecting consumer assessment of eco-labelled vehicles	Eco-label; Vehicle choice; Environmental perceptions	Journal article	2004-2005	Household	Transport	USA	Survey
Olshthoorn et al.	2018	Free riding and rebates for residential energy efficiency upgrades: a multi country contingent valuation experiment	Free rider; Subsidies; Energy efficiency; Contingent valuation	Journal article	2016	Household	Property	Multi country	Contingent valuation experiment
Orlov and Kallbekken	2019	The impact of consumer attitudes towards energy efficiency on car choice: Survey results from Norway	EVs; car choice; multinomial model; Norway	Journal article	2017	Household	Transport	Norway	Survey
Palmer et al.	2013	Assessing the energy-efficiency information gap: results from a survey of home energy auditors	Energy efficiency; Climate change	Journal article	2011	Household	Appliances	USA	Survey
Panzone	2013	Saving money vs investing money: Do energy ratings influence consumer demand for energy efficient goods?	Energy-efficiency gap; Energy-using products; Electricity; Consumer behaviour; AIDS model	Journal article	2010-2012	Household	Appliances	UK	Modelling
Papineau	2017	Energy Codes and the Landlord-Tenant Problem	Energy efficiency; Building codes; Real estate	Journal article	2007	Household	Property	USA	Modelling
Pedersen and Neergaard	2006	Caveat emptor- let the buyer beware! Environmental labelling and the limitations of 'green' consumerism	Environment management; Environmental labelling; Consumer values; Attitudes on behaviour	Journal article	.	Household	EE labels	.	Review
Phillips	2012	Landlords versus tenants: Information asymmetry and mismatched preferences for home energy efficiency	Choice experiment; Insulation; Random parameters logit	Journal article	.	Household	Appliances	New Zealand	Survey
Rahman et al.	2017	Energy Consumption Analysis Based on Energy Efficiency Approach: A Case of Suburban Area (PDF Download Available)	.	Journal article	3 months	Household	.	Malaysia	Survey

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Ramos et al.	2015	The role of information for energy efficiency in the residential sector	Energy efficiency; Information; Behaviour	Journal article	2008	Household	Appliances	Spain	Choice experiment
Ramos et al.	2016	Pro-environmental households and energy efficiency in Spain	Energy Efficiency; Investment; Behaviour; Habits	Journal article	2008	Household	Property	Spain	Discrete choice
Robinson and McAllister	2015	Heterogeneous Price Premiums in Sustainable Real Estate? An Investigation of the Relation between Value...	.	Journal article	2001-2011	Service	Property	USA	Data available; Hedonic model
Rodriguez-Fernandez et al.	2016	Online identification of appliances from power consumption data collected by smart meters	Smart meter; Power consumption; Big data; Machine learning; Supervised classification; Energy efficiency	Journal article	.	Household	Appliances	.	Evaluation of policies
Rohling and Schubert	2013	Energy labels for household appliances and their disclosure format	.	Journal article	.	Household	Appliances	.	Review
Roman de Lara and Galarraga	2016	The Paris Summit: The beginning pf the End of the Carbon Economy		Journal article	.	.	Policy	.	.
Ryan and Campbell	2012	Insight publications: Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements	.	Report	.	Household	.	Europe	Review
Ryan et al.	2011	Energy Efficiency Policy and Carbon Pricing	.	Report	.	.	Failures	.	Literature review
Salle	2013	Rational Inattention and Energy Efficiency	.	Journal article	.	Household	Appliances	USA	Model
Sammer and Wüstenhagen	2016	The influence of eco-labelling on consumer behaviour – results of a discrete choice analysis for washing machines	Information asymmetry, consumer behaviour, eco-labelling, choice-based conjoint analysis, discrete choice, household appliances, EU energy label, sustainability marketing.	Journal article	2004	Household	Appliances	Switzerland	Choice experiment
Sanchez et al.	2008	Savings estimates for the United States Environmental Protection Agency's ENERGY STAR voluntary product labelling program	ENERGY STAR; Energy efficiency; US greenhouse gas emissions	Journal article	2002-2015	Household	Appliances	USA	Review

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Sarkis	2017	A comparative study of theoretical behaviour changes models predicting empirical evidence for residential energy conservation behaviours	Green marketing; Conservation psychology; Residential energy efficiency; Voluntary green power market; Theory of planned behaviour; Value belief norm theory	Journal article	.	Household	Appliances	.	Review
Schleich et al.	2018	The impact of preferences over risk, time and losses on household adoption of energy efficiency technologies in Europe	Risk aversion; Time discounting; Present bias; Loss aversion; Energy efficiency; Adoption	Journal article	2016	Household	.	France, Germany, Italy, Poland, Romania, Spain, Sweden, and the United Kingdom	Interviews, choices and binary response model
Schmidt and Weigt	2013	Discount rates in consumers' energy-related decisions: A review of the literature	Energy consumption; Energy efficiency; Energy conservation; Economics; Sociology; Political science	Journal article	.	Household	.	.	Review
Schneider et al.	2000	Adaptation: sensitivity to natural variability, agent assumptions and dynamic climate changes	.	Journal article	1983-1992	Agriculture	.	USA	Theory
Schubert	2017	Purchasing energy efficient appliances - To incentivise or to regulate?	.	Journal article	2015	Household	Appliances	Switzerland	Online experiment
Shen and Saijo	2009	Does an energy efficiency label alter consumers' purchasing decisions? A latent class approach based on a stated choice experiment in Shanghai	Energy efficiency label; Consumers' purchasing decisions; Latent class model; Willingness to pay; China	Journal article	2012	Household	Appliances	China	Survey
Shiftan et al.	2012	The impact of company-car taxation policy on travel behaviour	Company car; Taxation policy; Travel behavior	Journal article	2008-2011	Service	Transport	Israel	Survey
Sorrell et al.	2004	The Economics Of Energy Efficiency: Barriers to Cost-Effective Investment	.	Book	.	.	.	.	.
Stadelman	2017	Mind the gap? Critically reviewing the energy efficiency gap with empirical evidence.	Energy efficiency gap; Discounting; Purchase decision; Behavioral anomaly	Journal article	.	Household	EE gap	.	Review
Stadelmann and Schubert	2018	How Do Different Designs of Energy Labels Influence Purchases of Household Appliances? A Field Study in Switzerland	Energy label; Purchase decision; Energy efficiency; Information provision; Attention; Field study	Journal article	2015	Household	Appliances	Switzerland	Field experiment

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Stanley et al.	2016	The price effect of building energy ratings in the Dublin residential market	Domestic building energy ratings; Hedonic valuation; Ireland	Journal article	2009-2014	Household	Property	Ireland	Data available; Hedonic model
Sterner	2011	Fuel Taxes and the Poor	.	Journal article	.	.	Transport	.	.
Sterner	2007	Fuel taxes: An important instrument for climate policy	Climate policy; Fuel tax; Demand elasticity	Journal article	.	.	Transport	OECD countries	Analysis of price elasticities
Student et al.	2017	Buildings behaving badly: a behavioural experiment on how different motivational frames influence residential energy label adoption in Netherlands	Building energy efficiency; Energy conservation; Energy efficiency; (Residential) energy label; Motivating conservation behaviour; Motivational (message) framing; Social norms; The Netherlands	Journal article	2012	Household	Property	Netherlands	Survey
Thøgersen and Møller	2008	Breaking car use habits: The effectiveness of a free one-month travelcard	Car use habits; Public transport; Economic incentive; Field experiment	Journal article	.	Service	Transport	Denmark	Field experiment
Tigchelaar	2011	Consumer response to energy labels in buildings. Recommendations to improve the Energy Performance Certificate and the Energy Performance of Buildings Directive based on research findings in 10 EU countries	.	Journal article	.	Household	.	.	Deliverable
Timma et al.	2017	Energy efficiency policy analysis using socio-technical approach and system dynamics. Case study of lighting in Latvia's households	System dynamics; Modelling; Lighting sector; Energy efficiency; Consumer behaviour	Journal article	2015-2040	Household	Lightning	Latvia	System dynamic modelling
Tong et al.	2016	Cross-domain feature selection and coding for household energy behaviour	Household energy behaviour; Demographic factors; Customer classification; Feature selection and coding	Journal article	2009-2010	Household	Appliances	Ireland	Survey
Tovar	2012	The structure of energy efficiency investment in the UK households and its average monetary and environmental savings	Energy efficiency adoption; Household space heating; Government policy	Journal article	2011	Household	Property	UK	Modelling

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Van Amstel et al.	2008	Eco-labelling and information asymmetry: a comparison of five eco-labels in the Netherlands	Eco-label; Information asymmetry; Consumer assurance; Producer compliance; Environmental impact	Journal article	.	Agriculture	.	Netherlands	Review
Vassileva and Campillo	2014	Increasing energy efficiency in low-income households through targeting awareness and behavioural change	Domestic energy consumption; Energy awareness; Consumer behaviour; ow income consumers	Journal article	2011	Household	Energy consumption	Sweden	Survey
Villca-Pozo and Gonzales-Bustos	2019	Tax incentives to modernize the energy efficiency of the housing in Spain	Energy efficiency; Tax incentives; Housing	Journal article	2009-2021	Household	Property	Spain	Evaluation of different tax instruments
Waechter et al.	2016	Letters, signs, and colours: How the display of energy-efficiency information influences consumer assessments of products	Energy efficiency; Consumer behaviour; Energy label; Heuristic	Journal article	2013	Household	Appliances	.	Online experiment
Waechter et al.	2015a	The misleading effect of energy efficiency information on perceived energy friendliness of electric goods	Energy label; Energy consumption; Energy efficiency; Decision-making; Decision heuristic; Rebound effect	Journal article	2013	Household	Appliances	.	Online experiment
Waechter et al.	2015b	Desired and Undesired Effects of Energy Labels—An Eye-Tracking Study	.	Journal article	2013	Household	EE labels	Switzerland	ANOVA
Wiley et al.	2010	Green Design and the Market for Commercial Office Space	Green design; Office; Leasing; Pricing	Journal article	2008	Household	Property	USA	Data available; Hedonic model
Wilson and Dowlatabadi	2007	Models of decision-making and residential energy use	Economics; Energy demand; Psychology; Sociology	Journal article	.	Household	.	.	Theory
Wong and Kinger	2017	Campaign energy efficiency labelling systems in the EU and Brazil: implications, challenges, barriers and opportunities	Energy rating systems; Energy efficiency labelling; EPBD; RTQ	Journal article	.	Household	EE labels	EU and Brazil	Comparative study
Yamamoto et al.	2008	Decision-making in electrical appliance use in the home	Decision-making; Electrical appliance use; Behavioural economics	Journal article	2006	Household	Appliances	Japan	Survey
Zabaloy	2019	Are energy efficiency policies for household context dependent? A comparative study of Brazil, Chile, Colombia and Uruguay	Energy efficiency; Energy policy; Household; Latin America	Journal article	2016-2017	Household	Failures	Brazil, Chile, Colombia and Uruguay	Transform qualitative information into quantitative data

Authors	Year of the article	Title of the article	Keywords	Type of publication	Study Year	Sector	Product category	Country	Methodology
Zhou and Yang	2016	Understanding household energy consumption behaviour: The contribution of energy big data analytics	Household energy consumption behaviour; Energy big data; Big data analytics; Energy informatics; Intervention strategies	Journal article	.	Household	Appliances	China	Survey

9 Annex - Chapter 2

9.1 A1: About the appliances sold during the field experiment

Store: ______________________________

Date: ______________________________

Type of appliance:

- ☐ Washing machine
- ☐ Fridge
- ☐ Dishwasher

Model: ______________________________

1. Post code of your habitual residence: _ _ _ _ _ _
2. Gender:
   - ☐ Male
   - ☐ Female
3. Select your age range:
   - ☐ 18-30 years
   - ☐ 31- 45 years
   - ☐ 45- 60 years
   - ☐ More than 60 years

Figure A 1: Short questionnaire used for consumers in the household appliances field experiment (English version)

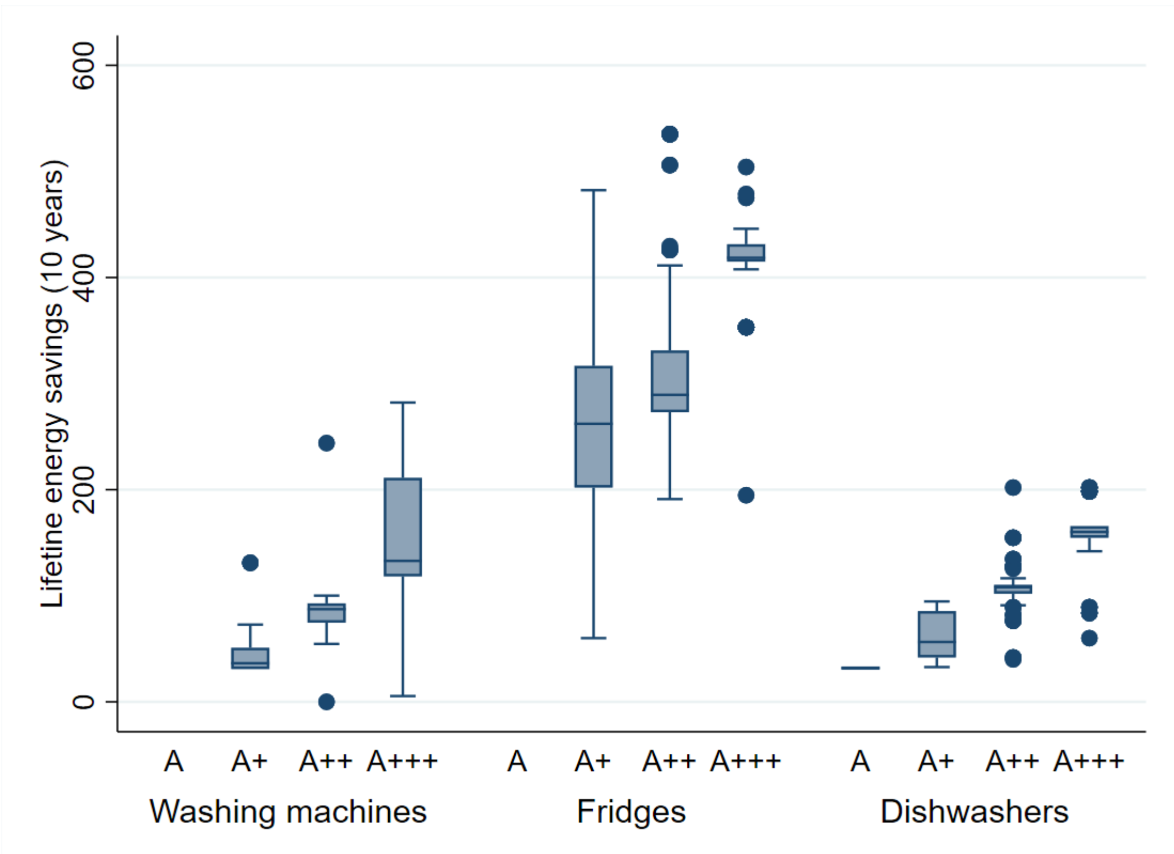

Figure A 2: Distribution of the household appliances sold during the field experiment

Table A 1: Characteristics of retailers

Ret	City	Province	Inhabitants	Size of city [37]	Washing machine	Fridge	Dishwasher	Total appliances sold	Predisposition towards the experiment
Ret 1	Gernika	Bizkaia	16,869	M	139	109	43	291	Good
Ret 2	Barakaldo	Bizkaia	100,313	L	136	73	29	238	Good
Ret 3	Bilbao	Bizkaia	345,122	L	373	165	127	665	Acceptable
Ret 4	Bilbao	Bizkaia	345,122	L	225	218	106	549	Good
Ret 5	Durango	Bizkaia	29,031	M	132	70	63	265	Acceptable
Ret 6	Mungia	Bizkaia	17,298	M	203	121	87	411	Good
Ret 7	Sopela	Bizkaia	13,047	M	24	18	12	54	Good
Ret 8	Getxo	Bizkaia	78,554	M	70	65	40	175	Acceptable
Ret 9	Colindres	Cantabria	8,331	S	200	148	64	412	Good
Ret 10	Ordizia	Gipuzkoa	9,998	S	209	152	70	431	Good
Ret 11	Tolosa	Gipuzkoa	19,386	M	224	79	97	400	Good
Ret 12	Zumarraga	Gipuzkoa	9,918	S	188	121	63	372	Good
Ret 13	Azkoitia	Gipuzkoa	11,587	M	227	107	37	371	Good
Ret 14	Ermua	Gipuzkoa	15,951	M	164	137	69	370	Good
Ret 15	Eibar	Gipuzkoa	27,380	M	135	81	26	242	Good
Ret 16	Zumaia	Gipuzkoa	9,979	S	224	79	97	400	Good
Ret 17	Donostia	Gipuzkoa	186,064	L	1,232	613	283	2,128	Acceptable
Ret 18	Bergara	Gipuzkoa	14,743	M	80	80	80	240	Good
Ret 19	Donostia	Gipuzkoa	186,064	L	24	18	12	54	Acceptable
Ret 20	Zumarraga	Gipuzkoa	9,918	S	122	62	34	218	Acceptable
Ret 21	Ainsa	Huesca	2,173	S	73	50	30	153	Good
Ret 22	Huesca	Huesca	52,282	M	349	317	167	833	Acceptable
Ret 23	Elizondo	Navarra	3,563	S	133	59	31	223	Good
Ret 24	Sangüesa	Navarra	5,002	S	146	71	47	264	Acceptable
Ret 25	Estella	Navarra	13,668	M	263	115	63	441	Acceptable
Ret 26	Tarazona	Zaragoza	10,713	M	81	62	39	182	Acceptable

[37] S (small) = less than 10,000; M (medium) = between 10,000 and 100,000; L (large) = more than 100,000

Table A 2: Average lifetime energy savings per product category and characteristics (Note: LES are not comparable among them).

Appliance		Average LES
Washing machine	6 kg	105.70€
	7 kg	126.95€
	8 kg	175.64€
	9 kg	116.80€
	10 kg	110.56€
Fridge		305.65€
Dishwasher	450 mm	86.78€
	600 mm	95.42€

Table A 3: Average prices per product category, energy efficiency level and treatment group

Washing machine	**A^{+++}**	**A^{++}**	**A^{+}**	**A**	**Overall**
Treatment 1	471.96€ N=238	410.85€ N=20	565€ N=1	.	472.28€ N=253
Treatment 2	494.49€ N=327	422.20€ N=20	594€ N=2	.	490.92€ N=349
Treatment 3	479.85€ N=217	477.46€ N=15	.	.	472.28€ N=253
Control	438.16€ N=584	441.05€ N=38	296.05 N=17	.	434.55€ N=639
Overall	**464.16€ N=1366**	**436.37€ N=93**	**339.30€ N=20**	**.**	**460.72€ N=1479**
Fridge	**A^{+++}**	**A^{++}**	**A^{+}**	**A**	**Overall**
Treatment 1	1136.93€ N=31	759.62€ N=64	436.60€ N=59	.	710.57€ N=154
Treatment 2	977.38€ N=37	795.01 N=76	446.31€ N=68	.	701.29€ N=181
Treatment 3	827.89€ N=25	685.05€ N=97	421.76€ N=75	.	602.94€ N=197
Control	847.93€ N=29	662.49€ N=195	465.76€ N=125	.	607.47€ N=349
Overall	**956.52€ N=122**	**704.81€ N=432**	**446.40€ N=327**	**.**	**643.75€ N=881**
Dishwasher	**A^{+++}**	**A^{++}**	**A^{+}**	**A**	**Overall**
Treatment 1	755.60€ N=5	545.81€ N=34	481.09€ N=26	459€ N=1	534.89€ N=66
Treatment 2	792.43€ N=19	495.93€ N=36	418.78€ N=32	334€ N=1	530.05€ N=88
Treatment 3	748.35€ N=11	472.21€ N=41	448.16€ N=40	.	494.77€ N=92
Control	587.40€ N=20	461.27€ N=97	427.24€ N=85	.	459.44€ N=202
Overall	**705.71€ N=55**	**483.24€ N=208**	**437.98€ N=183**	**396.50€ N=2**	**491.68€ N=448**

Table A 4: Descriptive statistics of variables used in the models

Washing machines	Number of observations	Mean	Standard deviation	Min	Max
Energy savings (€)	1599	149.965	52.13268	0	282.1
Efficiency (=1 if appliance is A+++)	1599	.91995	.2714555	0	1
Price (€)	1479	460.7262	180.7984	186	1508.87
Size of washing machine	1599	7.595997	.7115243	6	10
Type of embedding (=1 if free installation)	1599	.873671	.3323237	0	1
Water consumption (in L)	1576	9948.778	765.5639	7400	12900
Fridges	**Number of observations**	**Mean**	**Standard deviation**	**Min**	**Max**
Energy savings (€)	972	305.6589	75.16341	60.06	535.08
Efficiency (=1 if appliance is A+++)	975	.1435897	.3508532	0	1
Price (€)	881	643.7569	275.6021	198	2345
Volume of fridge (in L)	975	221.0185	40.16718	98	380
Volume of freezer (in L)	967	80.34023	16.95284	16	119
Small town (=1 if seller is from a small town)	976	.1956967	.3969395	0	1
Big city (=1 if seller is from a big city)	976	.4723361	.4994901	0	1
Dishwashers	**Number of observations**	**Mean**	**Standard deviation**	**Min**	**Max**
Energy savings (€)	522	93.00828	36.77416	30.94	202.02
Efficiency (=1 if appliance is A+++)	522	.1168582	.3215594	0	1
Price (€)	448	491.6848	175.3597	202.75	1399
Size (=1 if the size is 600mm)	522	.7203065	.4492791	0	1
Number of services	522	12.22031	1.963029	9	16
Water consumption (in L)	522	2944.954	380.4774	2100	4200
Small town (=1 if seller is from a small town)	522	.2318008	.4223872	0	1
Big city (=1 if seller is from a big city)	522	.4176245	.4936407	0	1

9.2 A2: Training of the sales staff

The training of sales staff consisted of 7 different points. This was done to cover all possible levels of knowledge of energy efficiency issues and household appliances. The structure was the following:

1. Introduction. Basic knowledge of EE. What is EE? Different energy efficiency levels.
2. How are the energy efficiency levels of the appliances under study (washing machines, fridges and dishwashers) calculated?
3. Why are there appliances which have the same energy efficiency level but different energy consumptions?
4. What are the main assumptions made in estimating average energy consumption under the EU energy efficiency label?
5. How are monetary lifetime energy savings estimated for each appliance (washing machine, fridge, dishwasher)?
6. What energy price is used for these estimations?
7. What lifetime is used in estimating monetary lifetime energy savings?

10 Annex - Chapter 3

10.1 A3: About the appliances sold during the field experiment

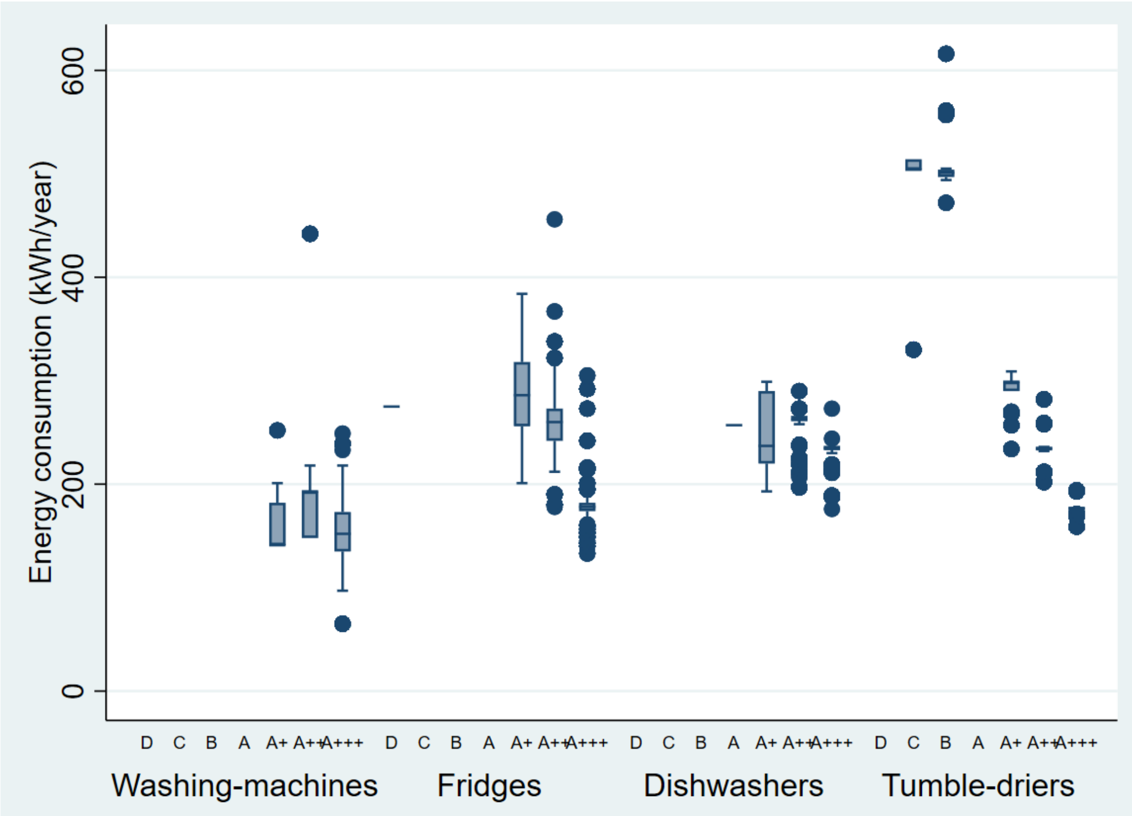

Figure A 3: Distribution of the household appliances sold during the field experiment.

Table A 5: Descriptive statistics

Washing-machines	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Capacity (kg)	25,554	8.044435	0.9457208	4	17
Water consumption (L)	25,554	10025.57	817.7853	6400	17000
Income (in the area where the store is located)	25,554	31127.77	7579.388	18332	45159
Price (€)	24,311	579.0299	207.0885	229	2349
Fridge	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Height (mm)	17,911	1936.627	95.51165	734	2040
Capacity- Volume of the freezer (L)	17,911	92.68226	11.38256	21	289
Income (in the area where the store is located)	17,911	31368.67	7493.066	18332	45159
Price (€)	11,097	929.2723	296.8308	379	6229
Dishwashers	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Width (=1 if the size is 600 mm)	16,093	582.9988	47.55289	450	600
Number of services	16,093	13.07078	1.518393	9	16
Water consumption (L)	16,093	2846.01	331.8684	1820	3920
Income (in the area where the store is located)	16,093	31518.98	7705.54	18332	45159
Price (€)	9,418	584.7331	175.7439	269	1545
Tumble drier	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Type of tumble-drier	6,976	0.2822534	0.5496487	0	2
Income (of the zone where the centre is located)	6,976	30641.4	8052.981	18332	45159
Price (€)	5,881	787.6103	234.8268	249	1649

Table A 6: Average prices per EE level and period. The highest catalogue prices per product category and EE level are marked in bold (Note: not all products are priced here. We searched for prices on the official website of the store, and several models did not appear there)

Washing-machine	**A+++**	**A++**	**A+**	**A**	**Overall**
Trat 1	572.73€ N=4731	459.63€ N=87	506.77€ N=18	.	570.45€ N=4836
Trat 2	585.54€ N=3634	644.46€ N=50	464€ N=2	.	586.37€ N=3686
Control	581.09€ N=15591	499.88€ N=177	419€ N=21	.	579.96€ N=15789
Overall	590.11€ N=23956	511.75€ N=314	459.73€ N=41	.	579.02€ N=24311

Fridge	**A+++**	**A++**	**A+**	**A**	**Overall**
Trat 1	1107.84€ N=955	857.72€ N=1576	577.27€ N=133	.	933.38€ N=2664
Trat 2	1095.70€ N=649	831.01€ N=774	531.12€ N=33	.	942.20€ N=1456
Control	1069.90€ N=2678	846.89€ N=4073	615.68€ N=226	.	925.00€ N=6977
Overall	1082.27€ N=4282	847.63€ N=6423	595.53€ N=392	.	929.27€ N=11097

Dishwasher	**A+++**	**A++**	**A+**	**A**	**Overall**
Trat 1	703.07€ N=472	540.91€ N=1234	448.82€ N=275	.	566.76€ N=1981
Trat 2	735.02€ N=372	550.27€ N=958	441.16€ N=284	.	573.65€ N=1614
Control	761.96€ N=1475	557.71€ N=3428	459.37€ N=920	.	593.91€ N=5823
Overall	745.65€ N=2319	552.75€ N=5620	453.91€ N=1479	.	384.73€ N=9418

Tumble-drier	**A+++**	**A++**	**A+**	**A**	**B**	**C**	**Overall**
Trat 1	1111.20€ N=183	802.24€ N=433	703.54€ N=11	.	512.39€ N=76	281.7€ N=10	841.82€ N=713
Trat 2	1834.61€ N=253	761.14€ N=467	684.62€ N=16	.	460.91€ N=45	265.37€ N=8	825.13€ N=789
Control	1025.34€ N=995	771.44€ N=2608	657.47€ N=59	.	456.55€ N=624	266.02€ N=93	772.02€ N=4379
Overall	1038.03€ N=1431	773.87€ N=3508	668.41€ N=86	.	462.51€ N=745	267.38€ N=111	787.61€ N=5881

10.2 A4: Training of the sales staff

The training of sales staff consisted of various points. The idea was to cover all possible levels of knowledge of EE issues and household appliances. The structure was the following:

1. Main concepts of the field experiment (e.g. treatments)
2. Calendar of the field experiment
3. Training session:
    a. Introduction. Basic knowledge of EE. What is EE? Different EE levels.
    b. How are the EE levels of the appliances under study (washing-machines, fridges and dishwashers) calculated?
    c. Why are there appliances which have the same EE level but different energy consumptions?
    d. What are the main assumptions made in estimating average energy consumption under the EU EE label?
    e. How are monetary lifetime energy savings estimated for each appliance (washing-machine, fridge, dishwasher)?
    f. What energy price is used for these estimations?
    g. What lifetime is used in estimating monetary lifetime energy savings?
4. Supplementary information. Tables with estimated monetary information. This part is mainly devoted to showing how the tables with the LEC could be used.

11 Annex - Chapter 4

11.1 A5: Risk elicitation task

Risk elicitation task adapted from Falk et al. (2016) **and Markanday et al.** (2022)**:**

Exercise explanation: In this exercise you will be presented with **five** different decisions. For each decision you will have to choose between a lottery and a sure payment. The lottery is the same in all situations: it gives you a 50% chance of receiving 30 tokens and a 50% chance of receiving nothing. The sure payment is different in each situation.

Q1. What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 16 tokens as a sure payment?

- Lottery: go to question 17
- Sure payment: go to question 2

Q2: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 8 tokens as a sure payment?

- Lottery: go to question 10
- Sure payment: go to question 3

Q3: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 4 tokens as a sure payment?

- Lottery: go to question 4
- Sure payment: go to question 7

Q4: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 6 tokens as a sure payment?

- Lottery: go to question 5
- Sure payment: go to question 6

Q5: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 7 tokens as a sure payment?

- Lottery
- Sure payment

Q6: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 5 tokens as a sure payment?

- Lottery
- Sure payment

Q7: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 2 tokens as a sure payment?

- Lottery: go to question 8
- Sure payment: go to question 9

Q8: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 3 tokens as a sure payment?

- Lottery
- Sure payment

Q9: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 1 token as a sure payment?

- Lottery
- Sure payment

Q10: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 12 tokens as a sure payment?

- Lottery: go to question 14
- Sure payment: go to question 11

Q11: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 10 tokens as a sure payment?

- Lottery: go to question 13
- Sure payment: go to question 12

Q12: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 9 tokens as a sure payment?

- Lottery
- Sure payment

Q13: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 11 tokens as a sure payment?

- Lottery
- Sure payment

Q14: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 14 tokens as a sure payment?

- Lottery: go to question 15
- Sure payment: go to question 16

Q15: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 15 tokens as a sure payment?

- Lottery
- Sure payment

Q16: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 13 tokens as a sure payment?

- Lottery
- Sure payment

Q17: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 24 tokens as a sure payment?

- Lottery: go to question 25
- Sure payment: go to question 18

Q18: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 20 tokens as a sure payment?

- Lottery: go to question 22
- Sure payment: go to question 19

Q19: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 18 tokens as a sure payment?

- Lottery: go to question 20
- Sure payment: go to question 21

Q20: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 19 tokens as a sure payment?

- Lottery
- Sure payment

Q21: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 17 tokens as a sure payment?

- Lottery
- Sure payment

Q22: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 22 tokens as a sure payment?

- Lottery: go to question 23
- Sure payment: go to question 24

Q23: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 23 tokens as a sure payment?

- Lottery
- Sure payment

Q24: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 21 tokens as a sure payment?

- Lottery
- Sure payment

Q25: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 28 tokens as a sure payment?

- Lottery: go to question 29
- Sure payment: go to question 26

Q26: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 26 tokens as a sure payment?

- Lottery: go to question 27
- Sure payment: go to question 28

Q27: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 27 tokens as a sure payment?

- Lottery
- Sure payment

Q28: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 25 tokens as a sure payment?

- Lottery
- Sure payment

Q29: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 30 tokens as a sure payment?

- Lottery: go to question 31
- Sure payment: go to question 30

Q30: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 29 tokens as a sure payment?

- Lottery
- Sure payment

Q31: What would you prefer: a 50 percent chance of winning 30 tokens when at the same time there is a 50 percent chance of winning nothing, or would you rather have 31 tokens as a sure payment?

- Lottery
- Sure payment

11.2 A6: Instructions for the experiment

This is an English translation of the text that researchers read aloud in each session of the lab experiment.

"THANK YOU FOR PARTICIPATING IN OUR EXPERIMENT!

Let's start the experiment. From this point on, you are not allowed to talk, watch what other subjects are doing or walk around the classroom. Please turn off your cell phone. If you have any questions or need help, please raise your hand and one of the researchers will come and talk to you. If you do not comply with the above rules, YOU WILL BE ASKED TO LEAVE THE EXPERIMENT AND NO PAYMENT WILL BE ISSUED. Thank you.

You will receive 15 euros for participating and an additional amount depending on the choices you make. This is an individual experiment and there are no right or wrong decisions. No subject will be able to identify any other subject by their decisions or by their final payments in the experiment. Each subject is identified by a number.

During the experiment you can earn experimental tokens (hereafter called tokens). Each token will be exchanged for euros: 200 tokens are equivalent to 1 euro. You will be paid in cash at the end of the experiment, strictly privately.

The experiment has 3 distinct parts. You can earn tokens in the first two parts. The last part is a short quiz.

1. PART 1

In this part you will be presented with five different decisions consisting of a choice between a lottery and a sure payment. The lottery will be the same in all situations: a 50% chance of receiving 30 tokens and a 50% chance of receiving nothing. The sure payment is different in each situation. In this part you can win up to 150 tokens.

To move to the next screen, press the OK button at the bottom right of the screen.

2. PART 2

In this second part you must decide to buy a refrigerator for your regular home, in 4 different scenarios. In each scenario:

- *You will be provided with basic information about 2 refrigerators.*
- *You will have 2000 tokens to pay for the refrigerator and its energy cost, which will depend on the price of energy.*
- *You must indicate which refrigerator you would buy with the available information.*

In each scenario you will be left with a number of tokens that will depend on the decision taken and the price of electricity. Two of the four scenarios will be chosen at random to determine the additional payment for this part 2.

Example: if at the end of part 2, in the two randomly chosen scenarios, you have 1200 tokens left, you will get a payment of 6€.

3. PART 3

A short questionnaire with questions about the difficulty of the exercise, how you felt, etc.

4. FINAL PAYMENTS

Once you have completed the experiment, the computer calculates the amount of the final payment based on your decisions and on the price of electricity. "

11.3 A7: Post-experiment survey

Difficulty of the lab experiment (Q1, Q2):

Question 1: Please rate how difficult you found the previous exercise on a scale from 1 to 5:

- ☐ 1 (not at all difficult)
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 (very difficult)

Question 2: To what extent did the exercise make you feel:

	***1** (Very slightly or not at all)*	**2**	**3**	**4**	***5** (Very much)*
Interested					
Distressed					
Excited/ enthusiastic					
Strong/ empowered					
Guilty					
Afraid					
Determined					
Nervous					

Personal experience regarding EE and the RENOVE rebate programme (Q3-Q8):

Question 3: Have you purchased any appliances for your home in the last 4 years?

- ☐ Yes
- ☐ No

Question 4: If you answered yes in Q3, could you tell us the level of energy efficiency?

- ☐ High energy efficiency level
- ☐ Low energy efficiency level
- ☐ I don't know/I don't remember

Question 5: If you answered "Low energy efficiency level" in Q4, could you please explain why?

- ☐ Because I could not afford anything else at the time of purchase.
- ☐ Because I did not give priority to energy efficiency at the time of purchase.
- ☐ I don't know/I don't remember
- ☐ Other reason: ________________________

Question 6: Have you had any experience with the RENOVE rebate programme for the acquisition of highly energy-efficient appliances?

- ☐ Yes
- ☐ No

Question 7: If you answered "Yes" in Q6: for what appliance? _________________

Question 8: Are you familiar with energy efficiency related concepts?

- ☐ Yes
- ☐ No

Environmental attitudes (Q9-Q11):

Question 9: Have you participated or do you participate in any environmental association, organisation or initiative?

- ☐ Yes
- ☐ No

- ☐ I don't know/I don't want to answer

Question 10: Please rate how concerned are you about the environment (e.g. air pollution, climate change, biodiversity loss).

- ☐ 1 (not concerned at all)
- ☐ 2
- ☐ 3
- ☐ 4 (very concerned)
- ☐ I don't know/I don't want to answer

Question 11: please indicate your degree of agreement or disagreement with the following statements:

		Strongly disagree	Disagree	Agree	Strongly agree	No opinion
a.	I am not willing to do anything about the environment if others do not do the same					
b.	Environmental impacts are frequently overstated					
c.	Environmental issues should be dealt primarily by future generations					
d.	I am willing to make compromises in my current lifestyle for the benefit of the environment					
e.	Policies introduced by the government to address environmental issues should not cost me extra money					
f.	Environmental issues will be resolved in any case through technological progress					
g.	Protecting the environment is a means of stimulating economic growth					

Socio demographic characteristics (Q12-Q18):

Question 12: indicate your year of birth: ________________

Question 13: Please indicate your education level:

- ☐ None
- ☐ Basic secondary school
- ☐ Upper secondary school
- ☐ Bachelor's degree/Higher vocational training
- ☐ Master's degree
- ☐ PhD

Question 14: indicate the number of people in your household:

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ More than 4

Question 15: your current residence is:

- ☐ Your own property
- ☐ Rented property
- ☐ Other

Question 16: Please specify your gender:

- ☐ Female
- ☐ Male
- ☐ Other

Question 17: Please indicate your current occupation: ____________

Question 18: Indicate which of the following social classes you belong to:

- ☐ Upper
- ☐ Upper middle
- ☐ Middle
- ☐ Lower-middle
- ☐ Lower

If you have any comments or opinions about the experiment, please indicate them below: _______________________

11.4 A8: Descriptive statistics of the variables used

Table A 7: Descriptive statistics of the variables used in Models 1, 2, 3 and 4

	Variable	Mean	Std. Dev.	Min	Max
Personal characteristics	***Gender***	0.4512195	0.4991389	0	1
	Age	44.43902	12.73573	19	69
	PeopleHome	2.670732	1.051495	1	5
	Education	0.6097561	0.4892989	0	1
	SocialClass	2.439024	0.8805682	1	4
	RiskLover	0.2926829	0.4563877	0	1
	RiskAverse	0.3170732	0.4667614	0	1
	EnvironmentalConcern	0.8109756	0.3927272	0	1
	EnvironmentalOrg	0.1646341	0.3719859	0	1
	Appliance	0.6707317	0.4713869	0	1
Experimental variables	***Interested***	0.6707317	0.4713869	0	1
	Excited	0.3231707	0.4691197	0	1
	Nervous	0.0792683	0.2709845	0	1
	FutureGenerations	0.2195122	0.4151839	0	1
	Difficulty	0.3780488	0.486385	0	1
	ConsumptionCriteria	0.347561	0.4776542	0	1
	LifetimeEnergyCostCriteria	0.445122	0.4985014	0	1
	RandomCriteria	0.0182927	0.1344181	0	1
Number of observations: 164					