Consumer purchases of energy-efficient cars: behavioural implications for policy

Ibon Galarraga[*,**], Josu Lucas[*] and Steffen Kallbekken[***]

Abstract

Improved energy efficiency can help reduce pollution, contribute to energy security, and help consumers save money. This paper explores car purchasing behaviour in order to draw implications for designing policies that will increase the demand for energy-efficient cars. To that end we calculate own and cross price elasticities of demand for cars with efficiency labels in the Spanish car market. The results show that the elasticities depend on assumptions about how consumers decide what car to purchase. If consumers are concerned about the absolute energy performance of cars independently of other attributes, demand for more efficient cars is more elastic than demand for less efficient cars. If consumers choose the car segment first and then the energy performance, the opposite result is found. The results suggest that both relative and absolute labelling schemes can be useful, depending on how consumers make their decisions. It might also be possible to design a mixed system.

Keywords: *Energy efficiency, car segments, price elasticities of demand, labelling.*

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Corresponding author: ibon.galarraga@bc3research.org

***Basque Centre for Climate Change (BC3). Alameda Urquijo 4, 4ª, 48008 Bilbao, Spain.**

****Economics for Energy, Doutor Cadaval 2, 3E, 36202 Vigo, Spain**

*****CICERO Center for International Climate and Environmental Research – Oslo. PO Box 1129 Blindern, 0318 Oslo, Norway.**

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Abstract

Improved energy efficiency can help reduce pollution, contribute to energy security, and help consumers save money. This paper explores car purchasing behaviour in order to draw implications for designing policies that will increase the demand for energy-efficient cars. To that end we calculate own and cross price elasticities of demand for cars with efficiency labels in the Spanish car market. The results show that the elasticities depend on assumptions about how consumers decide what car to purchase. If consumers are concerned about the absolute energy performance of cars independently of other attributes, demand for more efficient cars is more elastic than demand for less efficient cars. If consumers choose the car segment first and then the energy performance, the opposite result is found. The results suggest that both relative and absolute labelling schemes can be useful, depending on how consumers make their decisions. It might also be possible to design a mixed system.

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Introduction

"Energy efficiency is the invisible powerhouse in IEA countries and beyond, working behind the scenes to improve our energy security, lower our energy bills and move us closer to reaching our climate goals."

IEA Director Maria van der Hoeven at the launch of

the Energy Efficiency Market Report 2014,

A wide array of international research assessments, market analyses, institutions and politicians expect improved energy efficiency to deliver greenhouse gas emission reductions, reduced local air pollution, jobs, growth, increased energy security and large financial savings for households, companies and governments.

Energy efficiency can unquestionably generate multiple socioeconomic benefits (Ryan and Campbell, 2012). If the 2ºC climate change limitation target is to be achieved, the IPCC (2014) envisages investments in energy efficiency in housing, industry and transportation of as much as US$336 billion in the next two decades.

Transportation is one of the sectors where improved energy efficiency is expected to play a key role in meeting climate, environmental, energy and social policy goals. The Fifth Assessment Report of the IPCC finds that "energy efficiency measures through improved vehicle and engine designs have the largest potential for emission reductions in the short term" (Edenhofer et al. 2014).

In 2011 the world consumed more than 87.7 million barrels of oil per day. If no new policies are introduced, demand is expected to increase to more than 108.5 million barrels per day by 2035. More than 50 per cent of primary oil is consumed by the transport sector (and about 35 per cent by road transport). (IEA, 2012). The transport sector is responsible for 14 per cent of global greenhouse gas emissions (Edenhofer et al., 2014) and continues to be the sector with the largest growth. Its share of global oil consumption is expected to increase by an additional 15 percentage points by 2035, while the demand for oil in other sectors such as industry and buildings decreases. Some believe that the price of fuel might continue to rise in the near future despite the significant price fall in 2014 as fuel reserves become scarce, at least at reasonable exploitation costs. Energy security also suggests that reducing fuel dependency is a good strategy. In this context, reducing the oil dependency of the transport sector by switching to other energy sources such as gas, bio fuels or electricity, and enhancing energy efficiency is a sound strategy (IEA, 2012).

Investments in energy-efficient goods are lower than expected in the light of the potential financial savings that could be made by purchasing more efficient goods (Jaffe et al., 2009; Kounetas and Tsekouras, 2008). This is known as the “energy efficiency paradox”. There are many factors that contribute to explaining this phenomenon, such as asymmetric or insufficient information, lack of access to capital, differences between private and social discount rates, principal-agent issues that lead to maximising short-term profit rather than long-term strategic decisions, uncertainty regarding savings compared to certainty regarding costs, and the irreversible nature of the investment required (Abadie and Galarraga, 2012). Other behavioural barriers include the importance of frames or reference points (once a consumer is familiar with a product he/she tends to stick to it and use is it a basis for comparison with other similar products), the use of heuristics[1] and loss aversion (Policy Studies Institute, 2006). If we are to succeed in actually achieving the hypothesised benefits of improved energy efficiency we need to find ways to help consumers, companies and investors to make purchases that will generate multiple benefits. In many instances we will need to design smart government interventions, subsidies, regulations or information campaigns to overcome these barriers.

In this paper we analyse the scope for governmental measures to promote energy-efficient cars in the Spanish market. We examine the current situation as regards energy efficiency in the light-duty vehicle market in Spain, calculate price elasticities of demand and discuss how they can be used to improve the design of supporting policies. We focus on the light-duty vehicle market as a way of approaching the decision-making process of regular citizens in their daily life. Section 1 describes the European Union energy label scheme for cars, and how it is implemented in different ways in different EU Member States. Section 2 provides information on energy efficiency in the Spanish light-duty car market. Section 3 discusses how consumers

1 Heuristics refer to the fact that consumers make limited efforts to consider the benefits and costs of a decision, and instead use mental short-cuts to help them. Having too many choices often prevents consumers them from making a decision.

choose which car to buy, and the implications of how that choice is made. We calculate the own and cross price elasticities of demand using the Quantity Based Demand System (QBDS). The final section is devoted to conclusions and policy analysis.

1. EU energy labels for cars and supplementary policies

Energy labels are used as a policy instrument in many countries to convey information to consumers about the characteristics of goods (Lucas and Galarraga, 2014). The information contained in a label should help consumers make more rational choices in the sense of buying goods which consume less energy per service. Energy labels can be a sound choice if consumers hold incorrect beliefs about the energy efficiency of different products (e.g. car models), and if the labels are designed in a way that is effective in influencing consumer choices. Several studies indicate that consumers do indeed hold some incorrect beliefs about energy use, and that their behaviour does not match the predicted rational behaviour. Allcott and Wozny (2014), for instance, find that “US auto consumers are willing to pay just $0.61 to reduce expected discounted gas expenditures by $1”.

The EU has mandated energy labels for domestic appliances since 1995. In 1999 this was extended to include cars by Directive 1999/94/CE, which establishes a mandated labelling scheme under which retailers are required to display certain characteristics of the car such as size, fuel consumption and CO_2 emissions. It is an information labelling scheme.

The same Directive also regulates the use of a voluntary comparative labelling scheme with different categories of energy efficiency (from A, the most efficient, to G, the least efficient) in order to allow consumers to compare car models. The label also can include other information, such as running costs, annual tax costs, the amount of CO_2 emissions and additional attributes of the vehicle. This means that there are major differences between labels in different countries (Branningan, 2011). In Spain the Directive was transposed by Royal Decree 837/2002, and today all car retailers have to show both the standard EU label and the comparative label for their vehicles.

The use of the voluntary label has varied from one EU Member State to another mainly due to the lack of specific common requirements. As a consequence the level of recognition varies substantially, and is higher in those countries which have established the EU Energy

Labelling-style format (Carrol et al, 2014). For instance, Codagnone et al (2013) find that more than half of the respondents of a survey in different European countries were unfamiliar with the label; 40 per cent disagreed with the statement that it was easily recognisable; and 44.5 per cent agreed that car labels were unfamiliar to them. The differences also include the way in which categories of efficiency are calculated.

Some countries have established an absolute labelling scheme for all the cars in the market: the most efficient cars which pollute the least, usually the smallest cars, are labelled A class, while other cars, bigger or less efficient, are labelled B, C, D, E or G. This labelling system is used by most European countries, including France, Belgium, Denmark and the United Kingdom (Brannigan et al, 2011).

Other countries, such as Spain and Germany, have chosen to introduce a relative labelling scheme (Brannigan et al, 2011) where the label of the car depends on how much the fuel consumption and emissions of the car deviates from the average within its market segment (for instance small, mini, small sedan, big sedan, etc.). Hence, the relative label allows consumers to compare energy efficiency within a given car segment, but might make it more difficult to compare efficiency across car segments. In addition, this kind of scheme can sometimes be misleading as in some cases larger and heavier vehicles with absolute high emissions can achieve a better relative rating than smaller cars with lower emissions (Carrol et al, 2014).

The choice between absolute and relative labelling schemes has many implications, which are discussed below. Policy makers should aim to achieve the most energy-efficient car fleet which consumes as little fuel as possible and pollutes as little as possible at the minimum policy cost. The success of such a policy, however, depends on how well its design matches the process that consumers follow when deciding what car to purchase.

Labelling policy is often supplemented by financial incentives, such as a rebate for the most efficient goods (Galarraga et al, 2013). This is the case in Spain: the PIVE (Programa de Incentivos al Vehículo Eficiente) plan was implemented in 2012 (Resolution dated 28th December of 2012) and is currently in its 6th edition in 2014 (Royal Decree 525/2014). The PIVE subsidises the purchase of cars categorised as class A or B, electric cars, and cars which use gas or other alternative fuels. The subsidy is only applicable to cars up to a maximum price of €25,000, and it consists of a minimum discount of €1,000 in the price before taxes, which the producer or retailer has to apply, plus a subsidy of at least €1,000 after taxes financed by public funding earmarked for the PIVE. To the best of our knowledge there are, as yet, no studies assessing the impact of the policy.

2. Energy efficiency in the Spanish car market

To the best of our knowledge, there are no official statistics on the energy efficiency class of the new light-duty vehicles sold in the Spanish market. The National Association of Car and Truck Producers (*Asociación Nacional de Fabricantes de Automóviles y Camiones*, ANFAC) offers monthly data on the number of cars sold, but does not collect information on the energy efficiency performance of the cars sold. As a supplement to this information, The Spanish Energy Diversification and Saving Institute (*Instituto de Diversificación y Ahorro Energético*, IDEA) offers a list of the cars and models available and their energy efficiency attributes.

We merge information from these two databases in order to provide a better picture of the energy performance of cars sold in Spain (See Table 1). In 2012 a total of 699,589 cars were sold. We have identified the energy efficiency of 97.5 per cent of these cars. Most of the cars with unknown energy efficiency are sports and luxury cars: some special models cannot be found in the information provided by IDAE. In some other cases, one car model may have different energy efficiency options depending on other attributes such as power or the type of fuel, i.e. depending on the specific sub-model. In these cases we have divided the sales of that model proportionately to the number of sub-models in each energy efficiency category that could be found.[2].

Our numbers show that 41 per cent of the cars sold in Spain in 2012 were categorized as very efficient (A class). A and B label cars make up more than 75 per cent of all cars sold (see Table 1). There are significant differences, however, across car segments. Whether the high sales of efficient cars are a consequence of the current (and previous) PIVE rebate schemes remains to be fully understood. Other factors such as high fuel prices might also have influenced the high proportion of efficient cars sold.

2 Each car model usually has several variants or sub-models that could have different efficiency labels depending on other attributes. When this occurs and it was not possible to clearly identify the label, we divide the sales proportionally among the different energy efficiency classes.

How frequently the labels granted in a labelling scheme are reviewed also has an important effect on the proportion of efficient cars sold. In order to maintain the efficiency of the labelling system, it is necessary to periodically tighten the criteria for the ratings in an attempt to keep up with technological changes (Carrol et al, 2014). In the Spanish case, the formula used to make the classification should be updated annually according to the legislation (Resolution of 24th September 2012)[3]. In the case of Germany it is permitted to increase the energy classification to other classes such as A^{+} or A^{++} (Branningam, 2011).

Most of the cars sold were small (27.8 per cent) or small sedans (27.3 per cent). The share of sport and luxury cars was very low. The proportion of efficient cars varies from one segment to another: for instance the proportion of Sport, all types of SUV and Big Minivans with class A was very low, while more than half of all small and big sedans were class A. The energy efficiency of SUVs was very low, which can be explained by the limited presence of efficient SUVs on the market.

Table 1: Number of cars sold in Spain in 2012 per market segment, and their energy efficiency

	n. cars	%	% A class	% B class	% Others	Unknown
Small	194,616	27,82%	37,68%	50,70 %	11,62%	1,05%
Mini	35,164	5,03%	25,16%	38,39 %	36,45%	0,58%
Small Sedan	191,604	27,39%	53,40%	26,11 %	20,49%	0,13%
Big Sedan	85,310	12,19%	69,95%	18,75 %	11,30%	0,05%
Small Minivan	75,565	10,80%	42,51%	44,16 %	13,33%	0,58%
Big Minivan	10,573	1,51%	8,67%	32,16 %	59,17%	3,51%
Sport	2,176	0,31%	1,30%	21,61 %	77,09%	19,90%
Luxury	1,581	0,23%	52,16%	40,68 %	7,16%	33,08%
Executive	10,806	1,54%	33,98%	46,33 %	19,69%	26,37%
Small SUV	30,177	4,31%	2,97%	21,90 %	75,13%	2,64%
Medium SUV	52,198	7,46%	5,30%	18,72 %	75,98%	1,25%

3 The formula for calculating the efficiency of each car in Spain is $a * e^{(b*s)}$, where s is the area of the car; e = 2.7183; and a and b are two coefficients. Since 2012 these two coefficients have to be updated annually.

Big SUV	2,757	0,39%	0,00%	0,00 %	100,00%	0,40%
Luxury SUV	7,062	1,01%	0,00%	31,00 %	69,00%	29,51%
TOTAL	**699,589**		**41,07%**	**34,20 %**	**24,73%**	**1,53%**

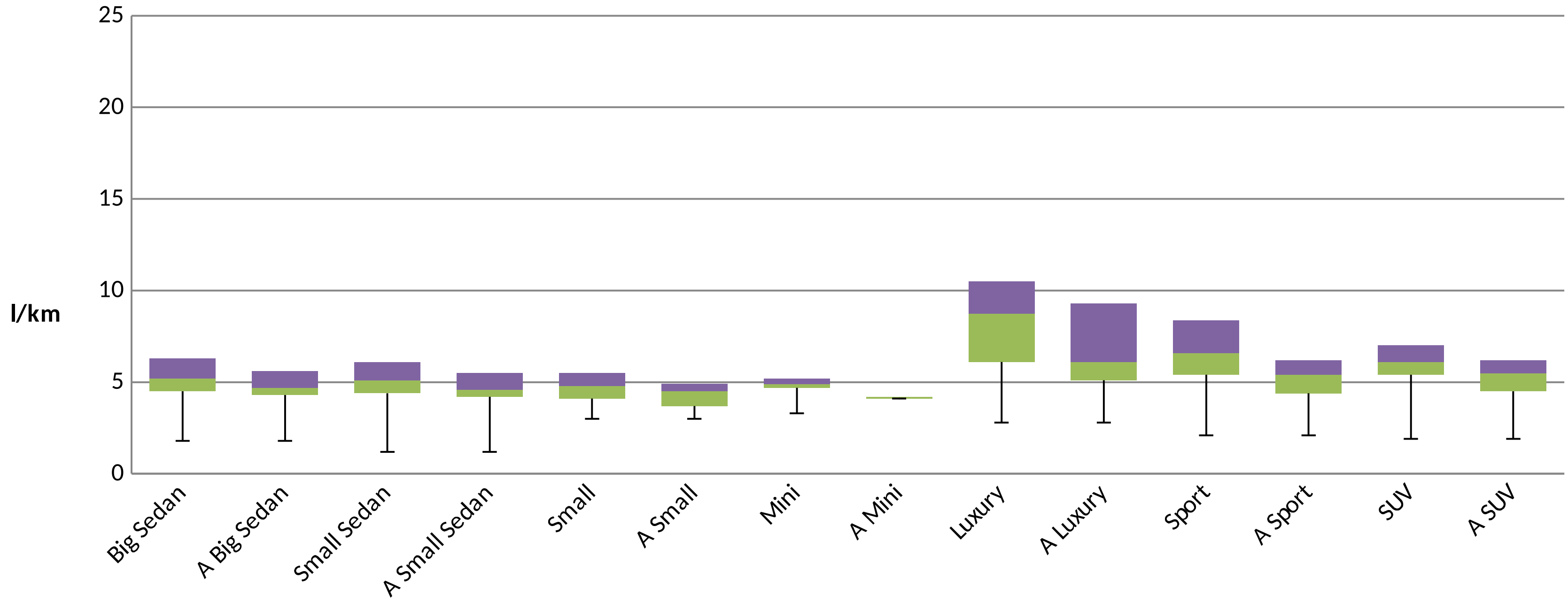
Source: Own calculations using data from IDAE and ANFAC.

As the labelling in Spain is relative, it is possible to find small cars labelled B or even C that consume significantly less fuel and emit less CO_2 than other bigger cars labelled A. One example is that the Alfa Romeo Mito, which is a small car consuming 4.2 litres of fuel per 100km and emitting 99g CO_2/km is labelled B, whereas a big KIA Optima sedan consuming 5.1 litres of fuel per 100km and emitting 133g CO_2/km, is labelled A. The reason is that the relative labelling scheme does not compare performance across segments.

To give an idea of the differences in emission performance and fuel consumption, Figure 1 shows the distribution per car segment in the Spanish market. Note that the green box refers to the distribution of cars within the first and second quartiles, while the pink one shows the distribution within the second and the third. The lines denote the minimum and maximum values.

Luxury cars show a significantly greater average consumption and emissions than other segments. They are followed by Sport, SUV and sedan vehicles. The difference between big and small sedans and small cars and minis is not so significant, although the variance is smaller in small cars and minis. However, as relative labelling does not account for these substantial performance differences across segments as it only focuses on best in class within the same segment, the distribution within the same segment can vary significantly compared to the absolute data.

Figure 1: Consumption per segment of the total fleet and the A class



Source: Own work from data from IDAE.

3. How do consumers choose to buy a car?

In order to design effective policies to increase the number of energy-efficient cars sold we need to understand how consumers choose a new car, and what role the energy efficiency of the car plays in that choice.

Many factors influence the choice of a car, including income, gender, age, household size, the number of drivers in the household, attitudes and driver personality, lifestyle and mobility (Policy Studies Institute, 2006). For instance, McCarthy and Tey (1998) (in OECD, 2008) find that in the US demand for energy-efficient cars is greater among women, minorities and younger people, while people with larger incomes tend to select larger, heavier, less efficient cars.

In this paper we consider two alternative hypotheses about how consumers make this decision. This is a simplification as many consumers make decisions using simultaneous or nested processes (Noblet et al., 2006). However, this simplification does fit well with the policy analysis in Brannigan et al., (2011) and serves well to explore the implications of choosing one type of labelling or the other[4]:

1) ***Absolute decision***: Consumers who are concerned about energy efficiency will select the most energy efficient car in the market independent of segment, that is, the car that consumes the least fuel and pollutes the least.

2) ***Relative decision***: Consumers first decide what type of car (i.e. the segment) they want to purchase, and then choose the most efficient one within the segment.[5]

We discuss the implications for public policy of hypotheses 1 and 2 in the sections that follow.

4 As far as we are aware no empirical studies are available to support the type of labelling chosen in EU Member States. If such studies existed they could have offered some insights on how purchasing decisions are made in each country.

5Another way might exist for consumers who have a very clear idea of the brand and even the model that they want, and then within those options select the most efficient one. This case is harder to discuss and has therefore been left out of the analysis.

3.1 Absolute Decision

This model of behaviour assumes that consumers who are concerned about energy efficiency search for cars in the whole market (i.e. across all segments) for the model that consumes the least fuel per km (and thus also pollutes the least). In this context, absolute labelling provides the most helpful information. Small and mini type cars labelled as class A are preferred, and demand is lower for the biggest cars such as sedans. Lane and Banks (2010) find that consumers in the UK value "fuel economy/running costs", "size/practicability" and "vehicle price" as the three most important factors to take into account at the time of purchasing a new car. Note that fuel economy is motivated more by running costs than actual environmental benefits. Therefore, some consumers might consider energy efficiency issues as it seems these prioritise fuel consumption over other attributes when deciding to buy a car.

If the policy maker wishes to supplement this policy with other policies such as a rebate system, a subsidy can be paid for purchases of cars with class A or, alternatively, a tax could be levied on inefficient cars[6]. The expected result of a rebate would be a change in the fleet, with smaller cars replacing bigger ones.

3.1.1 Calculating Own and Cross Price Elasticities of Demand for cars

An analysis of price elasticities of demand is useful in terms of policy design in order to understand how price changes are likely to affect the purchasing of efficient cars in the market. Ideally, policy makers would use a demand-supply system to properly set and adjust the rebate to be applied. For the purpose of this analysis we only look at the demand side as it is reasonable to assume an infinitely elastic supply function to account for the fact that if supply cannot meet the demand in the Spanish market, more cars will be imported (Galarraga et al., 2013). This will occur until the total demand is met.

6It is, of course, also possible to use a rebate that is a combination of both a tax on inefficient cars and a subsidy on the most efficient ones. See for example Langer (2005).

We consider efficient and non-efficient cars as substitute goods to a certain extent. We then use a demand system for close substitutes (the so-called Quantity Based Demand System, QBDS[7]) to calculate the own price elasticity for energy-efficient cars and the cross price elasticities between energy-efficient cars and other cars for Spain. The QBDS model was originally developed in Galarraga and Markandya (2004) for a case study on fair trade and organic labels and later applied to dishwashers (Galarraga et al, 2011) and washing machines (Galarraga et al, 2012).

Before price elasticities can be calculated with the QBDS, it is necessary to know the own elasticity of less efficient (other) cars, the income elasticity of demand for cars and the expenditure shares for both efficient and non-efficient (or less efficient) cars.

Whelan, G.A. (2007) estimate an own price elasticity of -0.34. Other studies such as Hymans (1971) provide information on the own price elasticities for automobiles for short and long periods of time that are much higher. Based on these studies we use values ranging from -0.35 to -1.2. Matas and Raymond (2008) show that car ownership income elasticity in Spain varied with the size of the municipality and over time. For the year 2000 they estimated a value of 0.548 for large, 0.454 for medium and 0.468 for small municipalities, and with much higher values for consumers owning two cars (ranging from 0.808 to 1.147), and for three or more cars (values from 1.644 to 2.176). Values seem to be declining with time. Based on this values we assume an income elasticity of 0.3, 0.5 and 1. Note that the QBDS imposes the mathematical constraint that the income elasticity of both type of cars should be smaller in absolute value than the own price elasticity of demand for other (O) cars.

The data on expenditure shares for non-efficient cars come from expenditure surveys conducted by the Instituto Nacional de Estadística (Spain's National Office of Statistics) in 2011[8]. We use the price premium estimate of 0.0592 per cent of the average car price found in Galarraga et al (2014) to calculate the expenditure shares for efficient cars (class A) (we name this good as "A"), non-efficient cars with classes below A (named "O") and a third good (named "X"), which is a composite that stands for the rest of the goods in the economy.

7 See Annex 1 for details of the QBDS model.

8 The expenditure share for new cars (07111) in 2012 was 1.61 per cent (INE, 2011).

The expenditure shares are:

W_O=0.009278206 W_A=0.006849049 W_X=0.98387275

The QBDS model works as a simplification of the Deaton and Muelbauer (1980) Almost Ideal Demand System (AIDS), except that it is defined in terms of quantity shares rather than expenditure shares. The QBDS is less data demanding, which is an advantage in these cases. Galarraga et al. (2011) show that results under some assumptions are robust and very similar for both models.

Table 2 shows the results of this estimation under the absolute decision making hypothesis.

Table 2A: Own and cross price elasticities of demand QBDS (Income elasticity = 1)			
Own O	Cross OA	Own A	Cross AO
-1.1	0.1000	-1.1355	0.1355
-1.2	0.2000	-1.2709	0.2709

Table 2B: Own and cross price elasticities of demand QBDS (Income elasticity = 0.5)			
Own O	Cross OA	Own A	Cross AO
-0.55	0.0500	-0.5677	0.0677
-0.85	0.3500	-0.9741	0.4741
-1.1	0.6000	-1.3128	0.8128
-1.2	0.7000	-1.4483	0.9483

Table 2C: Own and cross price elasticities of demand QBDS (Income elasticity = 0.3)			
Own O	Cross OA	Own A	Cross AO
-0.35	0.0500	-0.3677	0.0677
-0.45	0.1500	-0.5032	0.2032
-0.55	0.2500	-0.6387	0.3387
-0.85	0.5500	-1.0451	0.7451
-1.1	0.8000	-1.3837	1.0837
-1.2	0.9000	-1.5192	1.2192

The results suggest that demand for efficient cars (A) is slightly more elastic than demand for non-efficient cars (O). That is, demand for efficient cars decreases (increases) more than demand for non-efficient ones when the price of cars increases (decreases). The cross effects also suggest that changes in the demand for efficient cars are greater than the effect on other, less efficient ones. This difference increases as the price elasticities increase.

3.2 Relative Decision

This model of behaviour assumes that consumers first select a car segment according to their needs or preferences regarding attributes other than energy efficiency, and then incorporate energy efficiency considerations. As an example, take a family who need a big car with 7 seats. They will select a large car segment first, before (potentially) searching for a fuel efficient car within that segment. This is what Teisl et al. (2004) finds in focus groups for the US and Noblet et al. (2006) use the same rationale for their work. Furthermore, Noblet et al. (2006) find that consumers do not react to eco-labelling information even at class or segment level, but only at brand and model level. That is, only after consumers have chosen a brand and model do they incorporate fuel efficiency considerations. This is perhaps, the most extreme case of relative decision making, and thus not easy to address. Estimating demand elasticities for specific car brands requires a very rich, comprehensive database of a kind unlikely to become available in the short-medium term.

Some evidence of this behaviour can be found in European Parliament (2010), which considers that consumers go through two rounds in the decision process: first they select a vehicle segment, and secondly they apply the additional criteria, namely fuel efficiency, to make their final decision.

Lane and Banks (2010) also find that there is a perceived trade-off between fuel economy and vehicle size, i.e. once consumers choose a vehicle segment they are very rarely motivated to search for the most energy-efficient model as they underestimate the availability of highly efficient cars in that segment. This fact highlights the importance of and need for relative labelling to compare the energy efficiency of different models within a car segment. Furthermore, the study suggests that information on which model is "best in class" may be greatly appreciated by consumers.

If consumers use the relative decision process, then policy makers who wish to design an effective policy should aim for a relative energy efficiency labelling system. In fact, Peters et al. (2008) find that consumers show some, but limited, willingness to change behaviour in order to obtain incentives such as rebates, and that relative systems are better suited to implementing policies of this type. The limitation of this policy approach is that the policy does not directly incentivise the purchase of the most efficient cars in the complete market, but only the most efficient cars within each segment. This is, of course, an indirect way of achieving an efficient car fleet, and thus reducing fuel consumption and pollutant emissions.

If policy makers wish to supplement their policies with a rebate for purchasing efficient cars within each segment (class A), then obtaining information on the price elasticities of demand for each car segment becomes a very relevant issue.

3.2.1 Analysis of the own and cross price elasticities of demand for cars by segment

In this case we repeat the process of calculating the price elasticities of demand of efficient cars and non-efficient ones using the QBDS, but in this case for each car segment. Galarraga et al. (2014) also estimate a different price premium for different car segments with values ranging from 1.5 per cent for sedans to 7.5 per cent for Sport and Luxury cars.

To calculate the expenditure shares, in the knowledge that the share of efficient cars varies from segment to segment, we divide total expenditure by the market share of each segment (data shown in Table 1)[9]. As a price difference exists between car segments this assumption may not always hold. This is a caveat to be acknowledged, but the lack of official statistics requires an assumption to be made at this stage. The resulting expenditure shares are shown in Table 3.

9 We assume that the expenditure share for each segment is proportional to its share of total sales. Of course, it can be argued that as the price of small cars is lower, our result may overestimate the expenditure share on small cars. We have compared the expenditure shares obtained with those given by average prices and the results do not change much. The share for small cars is a little higher with the second method whereas that of luxury cars is a little lower. For the rest of the segments the values are quite similar.

Using this information, elasticities of demand ranging from -0.35 to -1.2 and an income elasticity of ranging from 0.3 to 1, we can calculate the price elasticities of demand for each car segment as shown in Tables 4a, 4b and 4c.

Table 3: Expenditure shares per car segment			
	W_O	W_A	W_X
Sedan	0.0026	0.0038	0.9936
Sport & Luxury	0.0002	0.0001	0.9997
Mini	0.0006	0.0002	0.9992
Small	0.0027	0.0017	0.9955
Minivan	0.0012	0.0008	0.9980
Four-wheel-drive (SUV)	0.0020	0.0001	0.9979

Table 4a: Own and cross price elasticities of demand per segment (Income elasticity = 1)							
SEDAN				**SPORT & LUXURY**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-1.1	0.1000	-1.0684	0.0684	-1.1	0.1000	-1.2000	0.2000
-1.2	0.2000	-1.1368	0.1368	-1.2	0.2000	-1.4000	0.4000
MINI				**SMALL**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-1.1	0.1000	-1.3000	0.3000	-1.1	0.1000	-1.1588	0.1588
-1.2	0.2000	-1.6000	0.6000	-1.2	0.2000	-1.3176	0.3176
MINIVAN				**SUV**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-1.1	0.1000	-1.1500	0.1500	-1.1	0.1000	-3.0000	2.0000
-1.2	0.2000	-1.3000	0.3000	-1.2	0.2000	-5.0000	4.0000

Table 4b: Own and cross price elasticities of demand per segment (Income elasticity = 0.5)	
SEDAN	**SPORT & LUXURY**

Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.55	0.0500	-0.5342	0.0342	-0.55	0.0500	-0.6000	0.1000
-0.85	0.3500	-0.7395	0.2395	-0.85	0.3500	-1.2000	0.7000
-1.1	0.6000	-0.9105	0.4105	-1.1	0.6000	-1.7000	1.2000
-1.2	0.7000	-0.9789	0.4789	-1.2	0.7000	-1.9000	1.4000
MINI				**SMALL**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.55	0.0500	-0.6500	0.1500	-0.55	0.0500	-0.5794	0.0794
-0.85	0.3500	-1.5500	1.0500	-0.85	0.3500	-1.0559	0.5559
-1.1	0.6000	-2.3000	1.8000	-1.1	0.6000	-1.4529	0.9529
-1.2	0.7000	-2.6000	2.1000	-1.2	0.7000	-1.6118	1.1118
MINIVAN				**SUV**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.55	0.0500	-0.5750	0.0750	-0.55	0.0500	-1.5000	1.0000
-0.85	0.3500	-1.0250	0.5250	-0.85	0.3500	-7.5000	7.0000
-1.1	0.6000	-1.4000	0.9000	-1.1	0.6000	-12.5000	12.0000
-1.2	0.7000	-1.5500	1.0500	-1.2	0.7000	-14.5000	14.0000

Table 4c: Own and cross price elasticities of demand per segment (Income elasticity = 0.3)							
SEDAN				**SPORT & LUXURY**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.35	0.0500	-0.3342	0.0342	-0.35	0.0500	-0.4000	0.1000
-0.45	0.1500	-0.4026	0.1026	-0.45	0.1500	-0.6000	0.3000
-0.55	0.2500	-0.4711	0.1711	-0.55	0.2500	-0.8000	0.5000
-0.85	0.5500	-0.6763	0.3763	-0.85	0.5500	-1.4000	1.1000
-1.1	0.8000	-0.8474	0.5474	-1.1	0.8000	-1.9000	1.6000
-1.2	0.9000	-0.9158	0.6158	-1.2	0.9000	-2.1000	1.8000
MINI				**SMALL**			
Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.35	0.0500	-0.4500	0.1500	-0.35	0.0500	-0.3794	0.0794
-0.45	0.1500	-0.7500	0.4500	-0.45	0.1500	-0.5382	0.2382
-0.55	0.2500	-1.0500	0.7500	-0.55	0.2500	-0.6971	0.3971
-0.85	0.5500	-1.9500	1.6500	-0.85	0.5500	-1.1735	0.8735
-1.1	0.8000	-2.7000	2.4000	-1.1	0.8000	-1.5706	1.2706
-1.2	0.9000	-3.0000	2.7000	-1.2	0.9000	-1.7294	1.4294
MINIVAN				**SUV**			

Own O	Cross OA	Own A	Cross AO	Own O	Cross OA	Own A	Cross AO
-0.35	0.0500	-0.3750	0.0750	-0.35	0.0500	-1.3000	1.0000
-0.45	0.1500	-0.5250	0.2250	-0.45	0.1500	-3.3000	3.0000
-0.55	0.2500	-0.6750	0.3750	-0.55	0.2500	-5.3000	5.0000
-0.85	0.5500	-1.1250	0.8250	-0.85	0.5500	-11.300	11.0000
-1.1	0.8000	-1.5000	1.2000	-1.1	0.8000	-16.300	16.0000
-1.2	0.9000	-1.6500	1.3500	-1.2	0.9000	-18.300	18.0000

The results show that in this case demand for the most efficient cars (class A) is less elastic than demand for non-efficient cars. This result is driven by the fact that the proportion of efficient vehicles in the market is lower than that of non-efficient ones for all segments except sedans. The range of elasticity values varies significantly for the cases of Mini, Sports and Luxury and SUV vehicles.

3.3. Improving the energy labelling scheme

We explore two alternative decision making processes in the car market. In the absence of an empirical test on how consumers actually make their choices in Spain, one could argue that a mix of consumers might exist, with some using the relative approach and some the absolute approach. Some evidence is reported in Noblet el al. (2006) using focus groups in the US that supports relative decision making, i.e. a two stage process. However, to the best of our knowledge, no similar studies exist for Spain or anywhere else in Europe.

Many countries have made decisions as to which type of labelling system to introduce, and we wonder whether those decisions are actually based on a deep understanding of the decision making process or not, but the truth is that we have not been able to find any supporting documents. Future work based on behavioural economics might help answer this question.

Spain chose the relative labelling scheme. Although the information provided by manufacturers and retailers shows the fuel consumption and the CO_2 emissions for each vehicle, the labelling scheme does not make for easy comparisons across segments. This policy is aimed at consumers who behave consistently with the relative decision making process. It remains to be seen whether Spanish consumers actually behave in such a way. Even if most of them do, one could argue that an absolute labelling scheme could lead some consumers to change their minds and decide on more efficient, probably smaller cars. This would, of course, lead to lower energy consumption and CO_2 emissions, but also to lower emissions of other important local pollutants such as particulates PM, NOx, CO and others.

In the absence of more complete information about how consumers actually make their decisions, an argument can be made for implementing both absolute and relative labelling schemes in some form of mixed labelling scheme where consumers can access both types of information. The Swiss labelling scheme offers information on some parameters based on absolute efficiency and also some relative ones. The scheme implemented in the Netherlands also offers both types of information and looks at the weighted average of the average CO_2 emissions of all cars in the same vehicle class (the weight is 75 per cent) and the average CO_2 emissions of all cars in the market (Branningan et al., 2011). These schemes might give some insights regarding how this can be done effectively.

4. Conclusions

This paper explores energy labelling schemes as a policy instrument for the promotion of efficient cars in Spain. These labels are often used to decide which car models qualify for inclusion in a rebate scheme to incentivise the purchase of more efficient vehicles. This is the case in Spain with the PIVE rebate scheme.

There are at least two ways of designing a labelling scheme for the car market: absolute and relative labelling schemes. Both target consumers, but they assume different underlying decision-making processes. The relative scheme is likely to be more effective for consumers who decide on other car attributes first (in particular choosing a segment) and then incorporate energy efficiency considerations. The absolute scheme targets consumers who place energy efficiency attributes at the same decision level as other characteristics of the vehicle. Depending on which scheme is to be promoted, different price premiums can be calculated and, consequently, different rebates should be used. Depending on the type of consumer, the demand response to changes in prices will also be different. This is a very important finding that suggests that customers should be properly characterised before the decision on the labelling scheme is taken. A mixed scheme might be the most suitable approach, but that does not help to settle the difficult decision of having to design the rebate scheme to favour one type of consumer. Of course the resulting label should not be so complex as to hinder consumers' understanding of the information provided (European Parliament, 2010).

We calculate elasticity values for both types of consumer in the car market in Spain. We find some differences in the sensitivity of the own price and cross price effects: this has implications for which policies will be the most effective. Note that as demand elasticities depend significantly on market shares and on the level of aggregation, our results are quite sensitive to changes in these two factors. This makes it crucial to further analyse the way in which consumers make decisions, as it will shed light on how these elasticities should be estimated and effective pricing policies can be.

With the results shown in this paper some interesting conclusion can be drawn. When absolute decision is assumed the demand for vehicles with higher efficiency level are greater than that for less efficient ones. Ceteris paribus, this means that pricing policies are likely to be more effective when applied to A labelled cars and therefore policies based on pricing systems may have a role to play in incentivising the purchase of more efficient vehicles. When relative decision is assumed, that is, when consumers choose the car segment first and then the energy performance, the opposite result is found. Additionally, in all but one of the cases the cross price elasticities AO are greater than cross OA, which means that impacts of changes in prices of the labelled car segment affect the demand for less efficient ones much less than in the opposite direction. This is an expected result when the share of non-efficient vehicles is greater than the share of A labelled ones. The exception to this is the case of A labelled Sedan vehicles with a greater share in this market segment that makes the cross elasticticity AO lower than the cross OA. That is, in this case changes in prices in A labelled cars affects the demand of non-labelled ones more. This effect cannot be noticed when showing values under absolute decision making hypothesis because the impacts on the rest of the segments overturn this.

The information provided by this paper should help to significantly improve the design of energy efficiency policies in Spain and elsewhere as it enables policy-makers to compare the effects of different policy instruments such as rebates, taxes or combinations of the two in so-called bonus-malus schemes.

Additionally, one could look at different examples from countries where absolute and relative labelling have been used and try to determine whether there have been any changes in purchasing behaviour after the introduction of the labelling. This approach would improve further our understanding of the effectiveness of each type of labelling scheme.

Finally, future research should determine how consumers actually make their purchasing decisions. This information would ultimately help to identify the most appropriate labelling and incentive schemes.

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ANNEX 1. Quantity Based Demand System (QBDS)

It is assumed that the market for an appliance is divided in two types of appliance: those with a “high label” for energy efficiency and those with a “low label”. The rest of the characteristics of the appliances are the same. So in this case the following variables are defined:

V_i: demand for quality i (energy efficiency) of good V (appliance) in comparable units. That is:

P_i: price of quality i of good V.

M: total expenditure.

P: aggregate price of good V

w_j: expenditure share of good V.

The demand for quality i of good V can be defined as follows:

$$\frac{V_i}{V} = \beta_i \left(\frac{P_i}{P}\right)^{-\infty} (1)$$

Where $\beta_i \geq 0$ is a constant and $\alpha \geq 0$ is the price sensitivity parameter.

If we now define a price index P as

$$P = \prod_i P_i^{s_i} \quad \text{where } s_i \geq 0 \text{ and } \sum s_i = 1 (2)$$

And the aggregate demand for all quality types as

$$V = A\left(\frac{P}{M}\right)^{-\mu} (3)$$

Where s_i is the weight for a quality i good in the price index for good V. A>0 is a constant and μ is the expenditure sensitivity parameter for the aggregate demand for the good.

The demand for each quality i for good V is homogenous of degree zero in prices and income.

The price elasticity $\in_{ii}$is given by

$$\in_{ii} = -\alpha + (\alpha - \mu) s_i (4)$$

While the cross price elasticity for good i with respect to the price of good j ($\in_{ij}$) is

$$\in_{ij} = (\alpha - \mu) s_j (5)$$

Finally, note that the Slutsky equation requires

$$\frac{s_j}{s_i} = \frac{w_j}{w_i} (6)$$

The additivity condition is obtained by differentiating the budget constraint with respect to M.

$$\sum_i w_i e_i = 1 (7)$$

As Galarraga and Markandya (2004) acknowledge, this has the limitation of requiring that quantities be broadly comparable but the advantage that subgroups of close substitutes are easier to handle and plausible own and cross price elasticities can be derived from limited data.

The QBDS is less demanding than the AIDS but it must also meet an additional condition: the income elasticity for close substitute goods must be the same. It is possible to derive the following conditions from the homogeneity constraint:

If $e_i > |e_{ii}|$ then $\sum_j e_{ij} < 0$ for all j≠i. Therefore at least one of the cross price elasticities has to be negative

and,

If $e_i < |e_{ii}|$ then $\sum_j e_{ij} > 0$ for all j≠I. and thus all the cross price elasticities could be positive.

This condition could be simplified by the fact that information on the composite good is not required. Having $e_i < |e_{ii}|$ which can be further simplified to $\acute{\alpha} > \mu$ is suffices to have positive cross price elasticities for all close substitutes. In short, this implies that the income elasticity of demand has to be smaller than the own price elasticity of demand of one of the substitute goods in absolute value.