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Evaluating the Role of Energy Efficiency Labels: the Case of Dish Washers

Ibon Galarraga, Mikel González-Eguino and Anil Markandya*

This article uses the hedonic approach to estimate how much is paid for the energy efficiency label on the dishwasher market in Spain. The estimated figure is 15.6% of the final price. This accounts for about 80€ of the average price. We use this estimate combined with a demand systems to obtain own and cross price elasticities of demand, vital for policy designing and analysis. This is done by combining the use of the estimate with the Quantity Based Demand System (QBDS) model to completely determine the demand function for different dishwashers. Finally, the elasticity results are compared with the ones calculated using the Linear Almost Ideal Demand System (LA/AIDS). The comparison of the results confirm that the QBDS model is easier to handle and less data demanding than the LA/AIDS model while providing reliable estimates of demand elasticities.

Keywords: demand systems, hedonic method, energy efficiency labelling,

household appliances (dishwashers)

JEL Classification: C13, C21

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1. Introduction

Energy transformation and consumption account for a significant share of global anthropogenic greenhouse gas (GHG) emissions. Energy efficiency policies are essential to reduce GHG emissions and save scarce economic resources. According to the International Energy Agency, energy efficiency measures can reduce up to 10-15% of global CO_2 per year at no cost (IEA 2009). The replacement of old appliances is judged to be one of the most cost-effective short term measures among these options (McKinsey 2009). However, private investments in energy efficiency that at first glance might seem economically worthwhile are not always undertaken. This so-called energy efficiency paradox (Jaffe et al 2004, Linares and Labandeira 2010) can be explained by existing barriers such as insufficient information, principal-agent problems, lack of access to capital or divergences between social and private discount rates. Understanding these barriers and what hinders real decisions to purchase highly efficient appliances is very important for designing more effective policies.

Energy labelling is one of the crucial measures to provide consumers with the necessary data to overcome the lack of information barrier. At the European level, the use of information on energy and other resources consumption in household appliances was regulated by Directive 92/75/ECC[1] and has been followed by many amending acts. Since 2008 a "Proposal for a Directive of the European Parliament and of the Council on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products SEC (2008) 2862" has been under review.

Energy labelling policy is acquiring a major importance in the light of the well-known EU Climate and Energy package (COD, 2008 and COM 2008) that sets the target of reducing energy consumption by 20% by 2020 and the goal of a 27% energy saving in the residential sector (European Council 2006). It is only fairly recent that information contained in the labels has been used to support other energy efficiency polices such as the direct subsidies to consumers when purchasing labelled appliances.

Within the economic literature, questionnaire information has been extensively used to elicit the price premium that environmentally friendly goods attract (Haji Gazali and Simula, 1994; Smith, 1990

[1] Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances.

and Levin, 1990). In the case of energy labels, there are also many studies such as Banfy et al (2008) that use choice experiment to evaluate consumers' willingness to pay for energy-saving measures.

Some interesting articles also exist in the case of household appliance. Mills and Scheleich (2010) study the relevance of class-A energy label attribute in the choice of five major household appliances using a survey for Germany. They find that residence characteristics (such as location or floor space) and regional electricity prices increase the propensity to purchase a class-A appliance and that socio-economic factors have little impact. Sammer and Wüstenhagen (2006) explore how energy labels affect consumer purchase decisions for washing machines using choice-based conjoint interviews in Switzerland. Consumers say that are willing to pay a premium of 30% for energy efficient washing machines.

Shen and Saijo (2009) conduct a choice experiment in Shanghai city to examine whether the energy label affects the choice of air conditioners and refrigerators. They conclude that consumers have a greater incentive to pay for energy labels in the case of appliances that are more frequently used (irrespective of the real energy saved). Other studies such as Markandya et al (2009) have looked at the energy efficient labels from a different approach, where decisions are assumed to be based on (a) the net cost of the appliance including the costs of operating it, (b) a willingness to pay for the public good of reducing emissions and (c) quality differences between products. The parameters are set based on the decisions actually in various markets.

The contingent approach has been often used in energy efficiency and energy label analysis, primarily due to the lack of data for labelled durables in many countries that would allow for traditional econometric analysis. However, there are some methodological limitations that are attached to these questionnaire-based studies (Diamond and Hausman 1994). Despite all the progress in survey design and results interpretation, it is always difficult to avoid what is often known in psychology as the intention-behaviour gap -- that is the difference between “customer attitude “and” customer behaviour. In other words, the difference between what consumers claim they are "ready to pay" and what they "really pay". While it is generally acknowledged that the existence of environmental awareness among consumers is necessary for the success of the energy-labelling schemes, it has also been noted that, unfortunately, increases in awareness may not always lead to changes in purchasing behaviour (Hemmelskamp & Brockmann, 1997). There are different papers in the literature that have tried to estimated this gap and they conclude that declared willingness to pay for goods is often between 61-96% above the true value (Schneider and Pommerehne 1981).

Some other indirect approaches, such as the well known hedonic price technique, have been proposed to complement these limitations of the analysis (Tiebout 1956, Lancaster 1966 and Rosen

1974). This method has been extensively used to estimate durable goods' characteristics such as: automobile demand (Griliches, 1961, Atkinson and Halverson, 1985, Couton et al., 1996), computers (Stavins 1997) and the housing market (Cropper et al., 1988 and Palmquist, 1984, Sheppard, S. 1999). For the case of environmental attributes, the technique has been more recently surveyed by Palmquist (1999) and some interesting applications can be found in Nelson (1982), Willis and Garrod (1991) or Brasington (2005). There are no applications, to the best of our knowledge, for the case of energy label and household appliances. Such studies would therefore be of great value to complement and compare survey based analysis and this paper is a contribution in that direction.

The first section of this paper estimates "actual willingness to pay" or "price premium actually paid" for energy efficient labels in the dishwasher market using the hedonic price technique. This technique allows us to estimate, ceteris paribus, a proxy of what the consumer pays for this single characteristic of the article. We analyse the case of the programme to renew household electrical appliances in Spain[2]. The programme[3] is part of the Energy Saving and Efficiency Action Plan[4] that sets a minimum of €50 as a lump sum subsidy to consumers (both public or private) willing to purchase highly efficient durables, i.e. labelled as class A or higher[5]; some Autonomous Communities have increased this premium to €70-90. The programme starts with an approved budget and it will run until a certain date or until the budget is exhausted. Therefore retailers are uncertain about how long the programme will last. The discount is applied by the retailer on the final price at the moment of purchase.

The second part of the study is devoted to the use of two complementary methodologies[6] to obtain information about price and cross elasticities. As this information proves to be crucial for both an optimal design of the policy and to support any fine tuning and revision of the policy outcome, studies need to be considered that can provide reliable estimates of the sensitivity of demand.

There are few studies that deal with elasticities of demand for household durables and only the odd one considers close substitutes such as labelled and non-labelled goods. Some of these studies are Jain and Rao (1990), for four durable goods using diffusion models or Golder and Tellis (1998) with a similar approach but for 31 different durables in the US economy. Revelt (1997) also estimates the impact of rebates and loans on residential customers' choice of efficiency level for the case of refrigerators. This

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[2] This programme is held by the Institute for Energy Diversification and Saving (IDEA, Instituto para la Diversificación y el Ahorro Energético) www.idae.es

[3]

[4] Regulated by Royal Decree 208/2005, 25 February 2005, on electrical appliances and electronic devices and the management of their wastes.

[5] As the programme is run by the Government of each of the Autonomous Communities, the amount of the subsidy can vary from 50 to 75 euro depending on the region analysed.

[6] An application of this methodology for the case of non-durables can be found in (Galarraga and Markandya 2004).

empirical research suggests that the price elasticity's of demand for household energy-consuming appliance are around -0.5 to -2. However, these studies do not provide estimates of cross elasticities, i.e., the sensitivity of the demand for labelled appliances to changes in the price of non-labelled ones and vice versa. The main reason for this is the lack of long-time series data for labelled goods.

The methodology presented here seeks to overcome this limitation by proving reliable estimates from limited data. The estimates presented here should provide valuable information to evaluate the current subsidy scheme and design future policy instruments for these and similar goods.

The paper is structured as follows: Section 2 presents the data and the hedonic model and Section 3 presents the main results. Section 4 presents the demand system models and Section 5 sets out the main results of our analysis. Section 6 lists some limitations of the study and presents conclusions and policy recommendations.

2. Data

The data analysed in the paper was collected from nineteen different retailers that includes a representative number of large shopping centres, small town-shops and medium-size specialist stores in the three provinces of the Basque Autonomous Community (BAC) in Spain during December 2009. As each Autonomous community manages its own version of the IDAE general programme, the subsidy size varies slightly among regions. Therefore it is reasonable to only focus on one of the markets that are affected by the instruments, in this case the Basque Market. The "Centro para el Ahorro y Desarrollo Energético y Minero" (CADEM) (part of the EVE group[7]) runs the programme locally.

For the purpose of the study, the stores could be assumed to be representative of the Spanish household appliances market. However, a greater dispersion of information is needed for a comparative analysis. One of the ongoing further developments of this research involves comparing the data among different Autonomous Communities in Spain and also among other European countries. In addition, similar studies are being carried out for other household appliances such as fridges and washing machines.

Out of the much greater number of dishwashers available in the whole Spanish market, only 183 models were displayed and readily available in these stores. These were broken down into for 27 different brands produced by 15 different producers, as listed in Table 1 below

[7] www.eve.es

Table 1. Producers and Brands

PRODUCERS (variable name)	BRANDS (variable name)
1. ELECTROLUX M.A.	AEG-ELECTROLUX (B1), ELECTROLUX (B13), ZANUSSI (B27)
2. SMEG ESPAÑA SA	APELL (B2), SMEG (B22)
3. INDESIT ELECTRODOMÉSTICOS, S.A.	ARISTON (B3), HOTPOINT-ARISTON (B15), INDESIT (B16)
4. FAGOR ELECTRODOMÉSTICOS, S. COOP.	ASPES (B4), DE DIETRICH (B10), EDESA (B12), FAGOR (B14)
5. BSH	BALAY (B5), BOSCH (B8), SIEMENS (B21)
6. BEKO ELECTRONICS ESPAÑA	BEKO (B6)
7. CANDY HOOVER	CANDY (B9), OTSEIN HOOVER (B19)
8. LG ELECTRONICS	LG (B17)
9. VESTEL	BLUESKY (B7)
10. MIELE S.A.	MIELE (B18)
11. TEKA INDUSTRIAL	TEKA (B23), THOR (B24)
12. MIDEA	WHITE-WESTINGHOUSE (B26)
13. EROSKI	ECRON (B11)
14. WHIRLPOOL IBERIA	WHIRLPOOL (B25)
15. ECI	SAIVOD (B20)

The collected information led to 318 observations as more than one brand is sold in more than one store. A total of 49 explanatory variables were used to estimate the price (in euro) of the different dishwashers sold in the market (46 of which are dummies) and hence identify the hedonic price function.

Table 2. Detail of the variables used

B1-B21: Brand dummy	If this brand=1, otherwise=0
LAB A+: Energy labelling A^+ dummy	If energy labelling A^+=1, otherwise=0
DRY: Drying efficiency dummy	If drying efficiency maximum A=1, otherwise=0
S1: (T1) SESTAO	If sold in this store=1, otherwise=0
S2: (T1) VITORIA	If sold in this store=1, otherwise=0
S4: (T2) SESTAO	If sold in this store=1, otherwise=0
S5: (T3) ARTEA	If sold in this store=1, otherwise=0
S6: (T3) MAX CENTER	If sold in this store=1, otherwise=0
S7: (T3) VITORIA	If sold in this store=1, otherwise=0
S8: (T3) SS	If sold in this store=1, otherwise=0
S9: (T3) ARRASATE	If sold in this store=1, otherwise=0
S10: (T4) BARAKALDO	If sold in this store=1, otherwise=0
S11: (T4) VITORIA	If sold in this store=1, otherwise=0
S12: (T4) SS	If sold in this store=1, otherwise=0
S13: (T5) BARAKALDO	If sold in this store=1, otherwise=0
S14: (T5) VITORIA	If sold in this store=1, otherwise=0
S15: (T6) ARRASATE	If sold in this store=1, otherwise=0
S16: (T6) SS	If sold in this store=1, otherwise=0
S17: (T7) EIBAR	If sold in this store=1, otherwise=0
S18: (T7) BILBAO	If sold in this store=1, otherwise=0
S19: (T8) IRUN	If sold in this store=1, otherwise=0
HEI: Height	Measured in millimetres
WID: Width	Measured in millimetres
DEPT: Depth	Measured in millimetres
CUT: Cutlery	Number of cutlery that could be washed.
COLOUR: Colour Steel dummy	If steel colour=1, otherwise=0
AFTIPS: Anti-fingertips dummy	If anti-fingertips=1, otherwise=0

The dummy variables were grouped as follows:

(a) *Brands:* 22 dummies to represent all the brands described in Table 1.

(b) *Energy label:* 1 dummies (A^+, other).

(c) *Dry efficiency:* 1 dummies (A, other).

(d) *Store:* 19 dummies for all the stores considered.

(e) *Colour:* 1 dummies for white and silver.

(f) *Anti finger prints:* 1 dummy.

As is standard when estimating regressions with dummy variables, one set of dummies represents the base case and is excluded from the regression. The remaining (non-excluded) variables that were inserted in the model are listed in Table 2.

After considerable experimentation, the preferred model can be written as follows,

$$LY = \alpha + \sum_{1}^{48} \beta_i Xi \; + u \text{, where } LY = \log(Y), \tag{1}$$

When this model is estimated using the Ordinary Least Squares (OLS) the diagnostic tests[8] (see Table 3) results show that heteroscedasticity is not present, normal distribution is obtained and the functional form is not rejected at 95% significance level. There is an R-Bar-Squared of 0.74, which suggests that the model broadly fits the data well and explains a large share of the variation in price.

We exclude various variables due to lack of significance from the results of the regression[9]. These are: dummy for Sestao T1 (S1), dummy for T1 Vitoria (S2), dummy for Sestao T2 (S4), dummy for T3 Artea Mall (S5), dummy for T3 Max-Center Mall (S6), dummy for T3 Vitoria (S7), dummy for T3 San Sebastian (S8), dummy for T3 Arrasate (S9), dummy for T5 Barakaldo (S13), dummy for T5 Vitoria (S14), dummy for T6 Arrasate (S15) , dummy for T6 San Sebastian (S16), dummy for Eibar T7 (S17) and dummy for Irun T8 (S19). The excluded variables are merged with the base case dummies in the revised regression.

Other deleted variables due to lack of significance were: dummy for Aspes brand (B4), dummy for Balay brand (B5), dummy for Bluesky brand (B7), dummy for Candy brand (B9), dummy for Ecron

[8] The econometric package used is Microfit 5.0.
[9] A deletion test was carried out to assure the correctness of the exclusion.

brand (B11), dummy for Edesa brand (B12), dummy for Hotpoint brand (B15), dummy for Indesit (B16), dummy for Savoid (B20), variables HEI and DEPT.

Table 3. Diagnostic Test for the Loglinear OLS Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= 21.5990 [.000]	F(1,269)= 19.6022 [.000]
B:Functional Form	CHSQ(1)= 3.3626[.067]	F(1,269)= 2.8748[.091]
C:Normality	CHSQ(2)= 5.5601[.062]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 2.1153[.146]	F(1, 316)= 2.1161[.147]
A:Lagrange multiplier test of residual serial correlation B:Ramsey's RESET test using the square of the fitted values C:Based on a test of skewness and kurtosis of residuals D:Based on the regression of squared residuals on squared fitted values		

3. Hedonic Function and Interpretation of Results

Once the non-significant variables were excluded and the equation re-estimated, we obtained the results shown in Table 4.

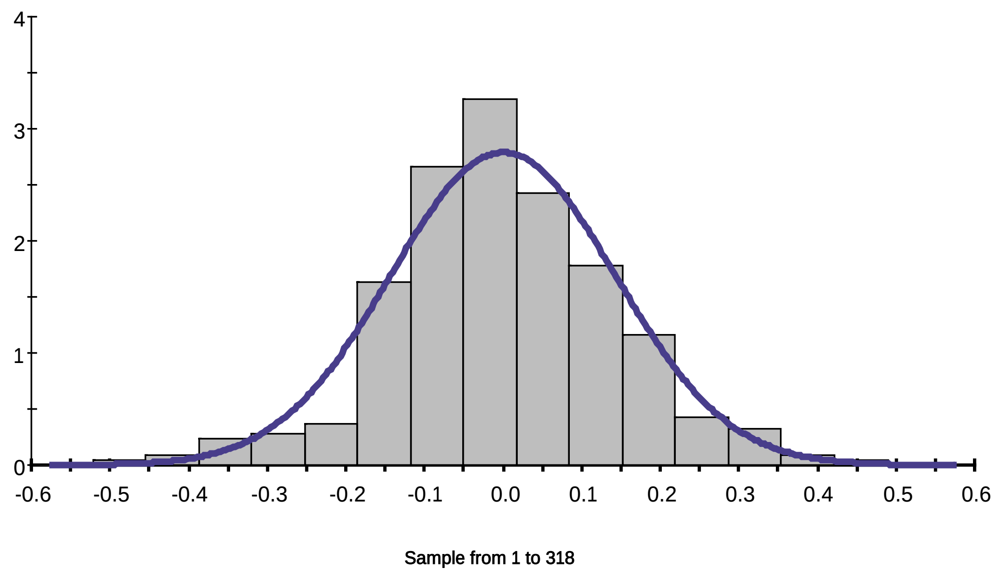
Table 4. Diagnostic Test for the Log linear OLS Model

Test Statistics	LM Version	F Version
A:Serial Correlation	CHSQ(1)= 24.7980 [0.000]	F(1, 294)= 24.8655 [0.000]
B:Functional Form	CHSQ(1)= 2.2290 [0.135]	F(1, 294)= 2.0753 [0.151]
C:Normality	CHSQ(2)= 11.8142 [0.003]	Not applicable
D:Heteroscedasticity	CHSQ(1)= 0.91344 [0.339]	F(1, 316)= 0.91031 [0.341]
A:Lagrange multiplier test of residual serial correlation B:Ramsey's RESET test using the square of the fitted values C:Based on a test of skewness and kurtosis of residuals D:Based on the regression of squared residuals on squared fitted values		

The goodness of fit remains much the same (0.74), the functional form is still not rejected at 95% confidence level and the tests for heteroscedasticity are satisfactory.

Since the tests for residuals normality are quite weak, compared with the graphic analysis, we analyse the histogram of residuals and the normal density graphic presented in Figure 1 (Trocóniz, 1987). According to this one could reasonably argue that we have an approximately normal distribution of residuals.

Figure 1. Histogram of Residuals and the Normal Density



According to our estimates, the coefficient for the variable for energy labels (LAB A+) is 0.156 and significant at 91%. At the market equilibrium price, the presence of the label will increase the price by 15.6% ceteris paribus.

It should be noted that the market price of the dishwashers did not change in the years of application as a consequence of the subsidy. We are thus referring to the pre-subsidy prices. At the time of collecting the data, the subsidy programme was not running anymore. The year 2009 can be used as a very good example to understand the rationale of this statement. The subsidy scheme was operative for the first months of the year and was cancelled when the budget was finished. As an exceptional measure, the Government decided to open a second round of subsidies for the second half of the year until very early December. The scheme was again not operative at the time of the data collection in mid- December.

The results indicate that for an estimated average price of washing machines of €514, the price will go up around €80 for an energy efficient product with label. Note that while the minimum subsidy regulated by the Royal Decree is €50, the BAC authorities subsidise up to €70-90. The result of this estimation poses many questions when compared to the subsidy figure as will be discussed later in this paper.

The other statistically significant results all have the expected signs and numerical values that are reasonable (Table 5).

Table 5. Parameter Estimates and Related Statistics

Variables	Estimated Coefficients	Standard Error	T-Ratio[Prob]
CONS	63,840	.094447	67.5937[.000]
B1	.20226	.035204	5.7454[.000]
B2	-.47178	.14939	-3.1581[.002]
B3	.32274	.14939	2.1604[.032]
B6	-.47546	.15015	-3.1667[.002]
B8	.22408	.032803	6.8310[.000]
B10	.67062	.077283	8.6775[.000]
B13	.22378	.033472	6.6854[.000]
B14	.11993	.027814	4.3118[.000]
B17	.29494	.035624	8.2790[.000]
B18	.76264	.041488	18.3822[.000]
B19	.18115	.080409	2.2529[.025]
B21	.24395	.039105	6.2384[.000]
LAB	.15600	.091058	1.7132[.088]
DRY	.10122	.026621	3.8021[.000]
S10	-.065733	.033373	-1.9696[.050]
S11	.073527	.027532	2.6706[.008]
S12	.12152	.042786	2.8402[.005]
S18	.18689	.027124	6.8902[.000]
WID	-.0019391	.2432E-3	-7.9738[.000]
CUT	.052204	.0082192	6.3515[.000]
COLOUR	.089869	.030493	2.9472[.003]

4. Analysis

The robustness of the premium estimate might be worth further investigation, but that is not the task of this paper. We are more interested in the use of hedonic price estimates to analyse further the market for energy efficiency labelled dishwashers.

Taking into account that, for policy purposes, the information on price differentials between energy efficient and other dishwasher is useful but not sufficient, or not even the most important factor, the method to obtain price elasticities needs to be further developed. That is, the sensitivity of demand for energy efficient dishwasher with respect to the prices of both energy efficient and other dishwashers, as along with guidance on the cost of supply of energy efficient and other dishwashers.

While there is no alternative to a more detailed supply side analysis, some information on the demand side can be obtained from the work that has been done so far. In this section, we report on the use of a demand system for close substitutes (the so-called Quantity Based Demand System, QBDS) to estimate the own price elasticity for energy efficient dishwashers and the cross price elasticities between energy efficient and other dishwashers for Spain, given the data from the hedonic estimation presented above. The model was originally developed in Galarraga and Markandya (2000) to provide a reliable method to obtain elasticity estimates from limited data. The QBDS is included as central part of Galarraga (2001) and it can also be found in Galarraga and Markandya (2004).

The results of this model are then compared with a more commonly used Linear Almost Ideal Demand (LA/AIDS) model. The latter has been extensively used to estimate housing attributes (Parsons, 1986), food demand (Molina, 1993 and 1994, Blanciforti and Green, 1983 and Fulponi, 1989) and tourism markets (Lanza, 1998). Most of these studies provide estimates of the own and cross price elasticities for broad groups of goods, e.g. food, clothing, energy, etc. (Anderson and Blundell, 1983); bread and cereals, fish etc. (Molina, 1994). The few models that look at close substitutes, such as labelled and non-labelled goods do not provide estimates of cross price elasticities. Moreover, they do not use the LA/AIDS or any complete demand system for the estimation. Hence, they cannot be used in any welfare analysis of shifts in taxes or subsidies.

4.1 A Quantity Based Demand System for Close Substitutes (QBDS)

In this case we want to assume that we have a market for dishwashers in which there are only two types of appliances: one with energy efficiency label and the other one without; being the rest of the characteristics equal. In this case we define the following variables:

V_i: demand for quality i (energy efficiency) of good V (dishwashers) in comparable units. That is, Kwh in the case energy efficiency.

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.

We then define the demand for quality i of good V as

$$\frac{V_i}{V} = \beta_i (\frac{P_i}{P})^{-\alpha} \tag{2}$$

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

Further we define a price index P as,

$$P = \prod_i P_i^{s_i} \quad \text{where } s_i \geq 0 \text{ and } \sum s_i = 1 \tag{3}$$

and the aggregate demand for all quality types as

$$V = A(\frac{P}{M})^{-\mu} \tag{4}$$

s_i is the weight for 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.

It is easy to confirm that the demand for each quality i of good V is homogeneous of degree zero in prices and income and that the price elasticity $\in_{ii}$ is given by

$$\in_{ii} = -\alpha + (\alpha - \mu)s_i \tag{5}$$

and the cross price elasticity for good i with respect to the price of good j, $\in_{ij}$, is given by

$$\in_{ij} = (\alpha - \mu)\ s_j \tag{6}$$

Finally we note that the Slutsky equation requires

$$\frac{s_j}{s_i} = \frac{w_j}{w_i} \tag{7}$$

which can be satisfied locally by selecting the values of s appropriately[10].

If we now differentiate the budget constraint with respect to M, we obtain the additivity condition;

$$\sum_i w_i \; e_i = 1 \tag{8}$$

This system is similar to the Deaton & Muellbauer’s (1980) AIDS demand system, except that it is defined in terms of quantity shares, not expenditure shares. It requires that quantities be broadly comparable, which is a limitation, but the advantage of working with this system is that subgroups of close substitutes are easier to handle, and one can derive plausible own and cross price elasticities from limited data.

The data collected provides us with some information on market share and, as a result of the hedonic analysis, on relative prices. Note that using the price information from the hedonic function allows us to treat dishwashers with energy label as one good and non-labelled energy efficient dishwashers as another. If an average price of both types of dishwasher is instead used, we would not control for differences in the rest of characteristics and the estimates might reflect other differences such as quality, origin and so on. Traditionally, calculations performed in such a way tend to significantly overestimate the price premium. The use of the information provided by the hedonic function fits well with the QBDS model.

We use the abbreviation “L” for dishwashers with energy label and “O” for the others or non-labelled ones. We also included a third good, the composite good “X”, which stands for the rest of the goods in the economy. From the information estimated using the hedonic methods, we can derive the implicit price that consumers are really paying for the “energy label” characteristic. This is 15.6% of the final price.

For each of the three goods considered, we get data from the market information collected in 2009 and the data from the expenditure surveys from Eustat (2009). We then calculate the expenditure share (w) on these three goods, considering that household durables have a useful life of 10 years.

$$w_O = 0.0016; \;\; w_L = 0.0002; \;\; w_X = 0.9982$$

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[10] There is of course no reason why the Slutsky equation should be satisfied in an aggregate demand equation. However it is often imposed as a condition to ensure that the system is behaves well and that the welfare analysis is not misleading.

The evidence from the literature (Jain and Rao op cit, Revelt op cit, Golder and Tellis op cit) suggests that the price elasticities of demand for normal dishwashers ($\in_{ii}$ in equation 5) by itself could be anything from -0.5 to -2. In addition, an income elasticity (μ) of 0.4 is also within the ranges of other studies.

From equation (7), given that $\sum_{1}^{3} s_i = 1$ and the above values of μ, and $\in_{ii}$, we obtain the elasticities shown below in Table 6.

Table 6. QBDS Estimates for Price Elasticities of Demand

	QDBS		
Price Elasticity of demand own O/O	**cross O/L**	**own for "L"**	**cross L/O**
-0.5	0.1	-1.2	0.8
-0.75	0.35	-3.2	2.8
-1	0.6	-5.2	4.8
-1.25	0.85	-7.2	6.8
-1.5	1.1	-9.2	8.8
-1.75	1.35	-11.2	10.8
-2	1.6	-13.2	12.8

Given α, s_i and μ, the hedonic function allows us to estimate the parameters β_i and A and hence to fully determine the demand equations for labelled and non-labelled dishwashers. Such demand equations, combined with supply cost data, allow us to estimate the impact of change in supply conditions, change in taxation etc. on the equilibrium prices and quantities in the dishwasher appliance market. The estimated impact of a one percent change in the price of non-labelled dishwasher on the demand for labelled dishwasher ranges from 0.8 to 12.8, depending on the assumed own-price elasticity of demand for non-labelled dishwashers. This parameter is of great importance in analysing the market for energy efficient dishwasher, as it tells us how much demand may be shifted over to the energy efficient appliances and thus turns to be extremely important to design supporting policies.

In addition, we have obtained information on how the demand for labelled dishwashers reacts to changes in the price of labelled ones (varying from -1.2 to -13.2) and also about the cross effect of changes in prices of labelled ones on the demand for non-labelled ones. The demand for labelled dishwashers is much more elastic than the demand for non-labelled one as can be expected.

We can, then, obtain from equation (8) the values for the composite good expenditure elasticity (e_x).

In the model, we are assuming that small changes in the composite good price would not affect the dishwasher appliances market, i.e., $\frac{\partial V_i}{\partial P^c} = 0$. We are thus assuming that there are no cross effects between the dishwasher market and the market for the composite good. This assumption is not unreasonable, given that this market is very small relative to the composite good market.

This data analysis is only indicative of what can be done. With more complex systems involving many different types of dishwasher, a larger set of parameters has to be determined but the method is the same as that developed here.

4.2 Applying LA/AIDS model

The estimates obtained with the QBDS model can be compared with the results obtained with the linear version of the Almost Ideal Demand System model (LA/AIDS).

For our analysis we have "O" & "L" and the composite good "X". Therefore our model for 'O' dishwashers can be written as,

$$w_O = \alpha_O + \gamma_{O/L} \ln P_L + \gamma_{O/X} \ln P_X + \gamma_{O/O} \ln P_O + \beta_O \ln(M / P) \tag{9}$$

where the Stone (1954) Price index is,

$$\ln P = w_O \ln P_O + w_L \ln P_L + w + w_X \ln P_X \tag{10}$$

The three conditions are,

Additivity:

$$\alpha_O + \alpha_L + \alpha_X = 1, \tag{11}$$

$$\gamma_{O/O} + \gamma_{L/L} + \gamma_{X/X} = 0 \tag{12}$$

$$\beta_O + \beta_L + \beta_X = 0 \tag{13}$$

Homogeneity:

$$\gamma_{O/L} + \gamma_{O/O} + \gamma_{O/X} = 0, \tag{14}$$

Symmetry:

$$\gamma_{O/L} = \gamma_{L/O}, \tag{15}$$

$$\gamma_{O/X} = \gamma_{X/O}, \tag{16}$$

As the LA/AIDS is much more data demanding than the QBDS, some restrictions have to be imposed in order to compare results of both models , that is, some more elasticity values have to be taken as given. The ‘extra’ values we use for this purpose are some of the values already calculated with the QBDS model as this seems to be the only reasonable method to compare both models. These elasticities are:

-Income elasticity for “O” and “T” goods are equal to 0.4,

-Own price elasticity for “X” is equal to -1,

-Own price elasticity for “O/O”, cross price elasticity “O/L” take the values calculated with the QBDS,

-Own price elasticity for “ot” takes, as in the QBDS model, the values -0.5, -0.75, -1, -1.5, -1.75, -2.

The formulae used for the calculation are reported in Table 7.

Table 7. Uncompensated Price and Income Elasticities Formulae

Elasticity	**Formulae**
Own price for good i	$e_{i/i} = \frac{\gamma_{i/i}}{w_i} - \beta_i - 1$
Cross price good i and j	$e_{i/j} = \frac{\gamma_{i/j}}{w_i} - \beta_i \frac{w_j}{w_i}$
Income	$e_i = 1 + \frac{\beta_i}{w_i}$
Green & Alston (1990)'s income[11]	$e_i = 1 + \frac{\beta_i}{w_i}[1 - \sum_j w_j \ln P_j (e_j - 1)]$

Applying these formulae to the data we obtain the estimates reported in Table 8.

Table 8. LA/AIDS Elasticity Estimates

	LA/AIDS $e_O = e_L = 0.4 \quad e_{X/X} = -1$						
Price Elasticicy of Demand own O/O	cross O/L	own for L	cross L/O	cross O/X	cross L/X	Cross X/L	Cross X/O
-0.5	**0.1**	-1.2	0.8	-0.000961731	6.66E-16	-0.000120216	9.98E-31
-0.75	**0.35**	-3.2	2.8	-0.000961731	1.22E-15	-0.000120216	9.98E-31
-1	**0.6**	-5.2	4.8	-0.000961731	1.78E-15	-0.000120216	-1.11E-16
-1.25	**0.85**	-7.2	6.8	-0.000961731	2.33E-15	-0.000120216	-2.22E-16
-1.5	**1.1**	-9.2	8.8	-0.000961731	2.89E-15	-0.000120216	-3.33E-16
-1.75	**1.35**	-11.2	10.8	-0.000961731	3.44E-15	-0.000120216	-4.44E-16
-2	**1.6**	-13.2	12.8	-0.000961731	4.00E-15	-0.000120216	-5.55E-16

*The numbers in bold are the values we have assumed as given in the model.

Comparing the results obtained from the LA/AIDS model with the ones obtained from the QBDS model, we find that the values estimated are much the same. As the values determined for the LA/AIDS

[11] The authors state that the correct form of the income elasticity for the LA/AIDS should be this one.

are set using the values obtained with the QBDS, this further supports the validity of the methodology. We have, therefore, used a model, which is essentially a special case of the well known LA/AIDS, but one that is much easier to handle and needs fewer parameters to be known. The limitations for the QBDS are, first, that the own price elasticity has to be greater than the income elasticity (in absolute value). Second, that it assumes the same income elasticity for labelled and non-labelled dishwashers. The latter would restrict the use of this model to close substitutes where the income elasticity is assumed to be equal or very similar12. It is, however, a very appropriate model to be used in labelling policies analysis that allows us to estimate elasticities and is less data demanding than the LA/AIDS.

5. Further Research

The price premium for energy efficient dishwashers has been studied here using the hedonic method. As quantities are simultaneously determined with prices and as prices are influenced by both supply and demand factors, the technique provides us with a premium that is the result of the interaction of all these factors. Future work should try to unravel the demand and supply effects.

The information from the premium has been combined with the QBDS to estimate own and cross price demand elasticities for labelled household appliances, dishwashers in this case. An ongoing working line is replicating the calculation for other household appliances with preliminary results being coherent with the ones presented here. The price premium paid in the market for fridges is close to 9.5%. Other preliminary estimates suggest a similar figure for washing machines.

A much more detailed analysis will allow for comparison among Autonomous communities in Spain as well as a specific policy analysis to evaluate the effectiveness of the subsidy programme. Economic literature will also benefit from international comparison.

6. Conclusion

Important global environmental problems such as climate change are nowadays driving energy efficiency policies due to the great energy savings targets of authorities worldwide. The EU 20-20-20 energy and climate package is a very good example of ambitious energy saving targets. In this context,

[12] This assumption, however, does not mean that the demand for labelled dishwasher reacts, in absolute terms, to changes in income the same way as the non-labelled demand, but in relative terms only. It, thus, assumes that the changes on demand due to changes on income in absolute terms on the labelled market are smaller than on the non-labelled market.

energy labelling is also acquiring a major role. Regulated since the early 1990s, it has been growing in importance since 2008 as a useful policy instruments for other policies such energy taxing or the lump sum subsidy schemes used in Spain.

The paper has proposed a methodology to overcome the two main limitations that handicaps the design of such lump sum subsidy schemes; (a) the lack of long term time series data for labelled goods that would allow for traditional econometric analysis and (b) the intention behaviour gap that poses a great bias in the questionnaire based studies.

The study has allowed us to estimate that when controlling for the rest of the variables, the price premium paid in the market for dishwashers carrying an energy efficient label is close to 15.6% of the final price. This percentage accounts for around €80.

While the market information suggests that the slightly larger amount should be sufficient to get consumers to switch from non-labelled appliances to labelled ones, the energy efficiency subsidy programme run by CADEM at the BAC pays up to €90 (a minimum of €50 is regulated for Spain as a whole). The first question that arises is whether the subsidy scheme has over-estimated this figure. Most probably because the method used to calculate this subsidy did not account for other characteristics attached to labelled appliances, when the truth is that, labelled appliances usually incorporate advanced equipment and are produced under the most recognised (and therefore expensive) brands on the market.

Other interesting questions could also be raised regarding the fact that these extra €10 could indeed be highly useful to overcome some barriers behind the energy efficiency paradox and to offset the positive externalities attached to less energy consumption. Preliminary information on the CADEM programme13 as well as the market data collected for this study strongly suggest that the policy has been extremely successful so far. Nowadays, nearly all of the household appliances sold in the market are labelled A or A+.

Many other policy analysis questions are relevant at this point but much more detailed information is needed to try to answer them.

The information on the price premium has been combined with the Quantity Based Demand System (QBDS) to estimate own price demand elasticities for labelled dishwashers and cross price elasticities of demand for both labelled and non-labelled. The calculations suggest that the demand for labelled appliances is much more elastic than the demand for non-labelled ones. In particular, for an own price elasticity of demand for non-labelled dishwashers ranging from -0.5 to -2, the own price elasticity of

[13] Personal conversation with the General Director and Vice-President of the CADEM.

demand for labelled appliances varies from -1.2 to -13.2. These results are important for a useful and reliable policy analysis

These results have also been compared with the ones from the well known LA/AIDS model. The fact that the same figures were obtained supports the use of the QBDS (a much less data demanding model) as a robust model for the analysis of close substitutes.

Future work should allow us to produce information on the welfare analysis side; essential for the fine tuning of effective and reliable energy efficiency policies.

References

Anderson, G. and Blundell, R. (1983), 'Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada.' *Review of Economic Studies*, vol. 50, pp. 397-410.

Atkinson, S. E. and Halverson, R. (1985), 'A New Hedonic Technique for Estimating Attribute Demand: An Application to the Demand for Automobile Fuel Efficiency.' *Review of Economics and Statistics*, vol. 66, pp. 417-26.

Banfi, S., Farsi, M., Filippini, M., Jakob, M. (2008), "Willingness to pay for energy-saving measures in residential buildings, *Energy Economics*, 30(2), 503-516.

Blanciforti, L. and Green, R. (1983), 'An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Community Groups.' *Review of Economics and Statistics*, vol. 65, pp. 511-15.

Brasington, David M., and Diane Hite. 2005. "Demand for Environmental Quality: A Spatial Hedonic Analysis." *Regional Science and Urban Economics* 35 (1) (January): 57-82.

COD (2008), "Proposal for a Decision of the European Parliament and of the Council on the Effort of Member States to Reduce Their Greenhouse Gas Emissions to Meet the Community´s Greenhouse Gas Emission Reduction Commitment up to 2020". 2008/0014 (COD)

COM (2008), Comunicación de la Comisión al Parlamento Europeo, al Consejo, al Comité Económico y Social Europeo y al Comité de las Regiones, "Dos veces 20 para 2020. El Cambio Climático, una Oportunidad para Europa".

Couton, C., Gaerdes, F. and Thepaut, Y. (1996), 'Hedonic Prices for Environmental Characteristics in the French Car Market.' *Applied Economics Letters*, vol. 3, pp. 435-40.

Cropper, Maureen, L., Leland B. Deck and Kenneth E. McConnell. (1988), 'On the Choice of Functional Form for Hedonic Price Functions.' *The Review of Economics and Sta*tistics, vol. 70, Nov, pp. 668-675.

Deaton, A. *and Muellbauer, J. (1980), 'An Almost Ideal Demand System.'* The American Economic Review, vol. 70(3), pp. 312-326.

Diamond, PA, and JA Hausman. 1994. Contingent valuation: is some number better than no number? *Journal of Economic Perspectives* 8(4):45–64.

European Council, 2006, Presidency Conclusions of 23/24 March 2006 (7775/1/06 REV1 of 18.05.2006).

Eustat, Cuentas Económicas, Instituto Vasco de Estadística, (2009). Vitoria. http://www.eustat.es/ (May 2010).

Fulponi, L. (1989), 'The Almost Ideal Demand System: An Application to Food and Meat Groups for France.' *Journal of Agricultural Econ*omics, vol. 40, pp. 82-92.

Jain, D., and Rao, R. (1990) Effect of price on the demand for durables: modelling estimation and findings, *Journal of Bussines & Economic Statistics*, 8 (2), 163-170.

Galarraga, I (2001), *On the Economics of Ecolabelling: A Case Study for Fair Trade Coffee in the UK*. PhD thesis, University of Bath.

Galarraga, I and Markandya A. (2000), "The Use of Hedonic Methods to Evaluate the Economics of Eco-labelling: A Case Study for United Kingdom". *Department of Economics and International Development Working Papers*. University of Bath.

Galarraga, I. and Markandya, A. (2004), 'Economic Techniques to Estimate the demand for Sustainable Products: A Case Study for Fair Trade and Organic Coffee in the United Kingdom.' *Economía Agraria y Recursos Natu*rales, vol 4,7, pp. 109-134.

Golder, P. and G. Tellis. Beyond Diffusion: An Affordability Model of Growth of New Consumer Durables, *Journal of Forecasting*, 17, 250-280.

Green, R. and Alston, J. M. (1990), 'Elasticities in LA/AIDS Models.' *American Journal of Agricultural Economics*, vol. 72, pp. 442-45.

Griliches, Z. (1961), 'Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change.' In *The Price Statistics of the Federal Government*. New York: Columbia University Press.

Haji Gazali, B. and Simula, M., (1994), *Certification Scheme for All Timber and Timber Products*. Cartagena: ITTO, May.

Hemmelskamp, J. and Brockmann, K.L. (1997), "Environmental Labels: The German 'Blue Angel". *Futures*, vol. 29 (1) pp. 67-76.

IEA (2009): *Implementing Energy Efficiency Policies: are IEA member countries on track?* OECD/IEA, Paris.

Jaffe, A.B., Newell, R.G. and Stavins, R.N. (2004) *Economics of energy effici*ency, Encyclopedia of Energy 2: 79-90.

Jain, D., and Rao, R. (2005), "Effect of price on the demand for durables: modelling estimation and findings", *Journal of Bussines & Economic Statistics*, 8 (2) 163-170.

Lancaster, K.J. (1966), "A New Approach to Consumer Theory". *Journal of Political Economy*, vol. 74, April. pp. 132-157.

Lanza, A. (1998), *Tourism Specialisation and Economic Growth*. Ph.D Dissertation, University of London.

Levin, G. (1990), 'Consumers Turning Green: JWT.' *Advertising Age*, vol. 61.

Linares, P. and Labandeira, X. (2010), Energy Efficiency: Economics and Policy', *Journal of Economic Surveys*, forthcoming

McKinsey (2009) Pathway to a Low-Carbon Economy : Version 3 of the Global Greenhouse Gas Abatement Cost Curve, McKinsey&Company.

Markandya, A., Arigoni Ortiz, R., Mudgal, S. And Tinetti, B. (2009). 'Analysis of tax Incentives for Energy-Efficient Durables in the EU'. *Energy Policy,* 37, pp. 5662-5674.

Mills, B. and Scheleich, J. (2010) What´s driving energy efficient appliance label awareness and purchase propensity?, *Energy Policy*, 38, 814-825.

Molina, J. A. (1993), 'Evolución de la Demanda de Productos Alimenticios en los Países Mediterráneos: Estimaciones del Sistema de Demanda Casi Ideal.' *Invest. Agrar: Econ.*, vol. 8(3).

Molina, J. A. (1994), 'Food Demand in Spain: An Application of the Almost Ideal Demand System.' *Journal of Agricultural Economics*, vol. 45(2), pp. 252-258.

Nelson, J.P. (1982) Highway noise and property values: a survey of recent evidence, *Journal of Transport Economics and Policy*, XIC, 37-52.

Palmquist, R. B. (1984), 'Estimating Demand for the Characteristics of Housing.' *Review of Economics and Statistic*s, vol. 66, pp. 394-404.

Palmquist, R. B. (1999) Hedonic models, in van den Bergh, J.C.J.M. (ed.) *Handbook of Environmental and Resource Economics*, Edward Elgar, Cheltenham.

Parsons, G. R. (1986), 'An Almost Ideal Demand System for Housing Attributes.' *Southern Economic Journal*, vol. 53, pp.347-63.

Revelt, D. and K. Train. Mixed Logit with Repeated Choices: Household's Choice of Appliance Efficiency Level. *Review of Economics and Statistics*. 80: 1-11.

Rosen, S. (1974), 'Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition'. *Journal of Political Economy*, Jan-Feb 1974, Vol.82(1), pp.34-55.

Sammer and Wüstenhagen (2006) The influence of eco-labelling on cosumer behavior, results of a Discrete Choice analysis for Washing Machines. *Business Strategy and the Environment*, 15, 185-199

Shen J. and Saijo, T. (2009), "Does an energy efficiency label alter consumers' purchasing decisions? A latent class approach based on a stated choice experiment in Shanghai", *Journal of Environmental Managemen*t, 90 (11) 3561-3573.

Sheppard, S. 1999. "Hedonic Analysis of Housing Markets." In *Handbook of Urban and Regional Economics*, Volume 3, Applied Urban Economics, edited by P. Cheshire and E. S. Mills (North-Holland).

Schneider, F., Pommerehne, W.W., 1981. On the rationality of free riding: an experiment. *Quarterly Journal of Economics* 76, 689–704.

Smith, G. (1990), 'How Green is my Valley.' *Marketing and Research Today*, vol. 18(2), pp. 76-82.

Stavins, J. (1997), Estimating Demand Elasticities in a differentiated product industry: the personal computer market, *Journal of Economics and Business*, 49: 347-367.

Stone, R. (1954), 'Linear Expenditure Systems and Demand Analysis: An Application to the Pattern of British Demand.' *Economic Journal*, vol. 64, pp. 511-527.

Tiebout, C. M. (1956), 'A Pure Theory of Local Expenditures.' *Journal of Political Economy*, Oct 1956, vol. 64(5), pp.416-424.

Trocóniz, A. Fz. (1987), *Modelos Lineales: regresión, análisis de la varianza, diseños experimentales*. Argitarapen Zerbitzua/Servicio Editorial. Euskal Herriko Unibertsitatea/Universidad del País Vasco.

Willis, K. and Garrod, G. (1991) An individual travel cost method of evaluating forest recreaction, *Journal of Agricultural Economics*, 42, 33-42.

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