BASQUE CENTRE FOR CLIMATE CHANGE
Klima Aldaketa Ikergai

# Economic Efficiency, Environmental Effectiveness and Political Feasibility of Energy Efficiency Rebates: the Case of the Spanish Energy Efficiency "Renove" Plan.

Ibon Galarraga, Luis María Abadie and Alberto Ansuategi

February 2013

LOW CARBON PROGRAMME

Low Carbon Programme:
Fundación Repsol / UPV-EHU / BC3
Joint Initiative on the Economics and Policy of Energy and Climate Change

BC3 WORKING PAPER SERIES

2013-05

The Basque Centre for Climate Change (BC3) is a Research Centre based in the Basque Country, which aims at contributing to long-term research on the causes and consequences of Climate Change in order to foster the creation of knowledge in this multidisciplinary science.

The BC3 promotes a highly-qualified team of researchers with the primary objective of achieving excellence in research, training and dissemination. The Scientific Plan of BC3 is led by the Scientific Director, Prof. Anil Markandya.

The core research avenues are:

- Adaptation to and the impacts of climate change
- Measures to mitigate the amount of climate change experienced
- International Dimensions of Climate Policy
- Developing and supporting research that informs climate policy in the Basque Country

This Working paper has been produced under the Low Carbon Programme initiative:
http://www.lowcarbonprogramme.org/

The BC3 Working Paper Series is available on the internet at
http://www.bc3research.org/lits_publications.html

Enquiries (Regarding the BC3 Working Paper Series):

Roger Fouquet

Email: roger.fouquet@bc3research.org

www.bc3research.org



Note: If printed, please remember to print on both sides. Also, perhaps try two pages on one side.

# Economic Efficiency, Environmental Effectiveness and Political Feasibility of Energy Efficiency Rebates: The Case of the Spanish Energy Efficiency "Renove" Plan.

*Ibon Galarraga º*, Luis M. Abadie º* and Alberto Ansuategi**

**Abstract**

Energy labels are used to promote the purchase of efficient appliances. Many countries in Europe use subsidies (namely energy efficiency rebates) to support these purchases as it is the case of Spain. A figure ranging from 50 to 105€ subsidy has been granted in the past for the acquisition of the most efficient appliances. This paper first analyses the impact of a 80€ subsidy on the dishwasher market and compares the results with a 40 € tax for non-labelled ones. The results take into account the effects that the policies generate in the market segment that is a close substitute, that is, cross effects. The paper shows that the subsidy is expensive for the Government, generates some welfare losses and it also generates a rebound effect as a consequence of the increase in the total number of appliances sold. The 40 € tax does not cost money to the Government, it generates a lower welfare loss and reduces the energy bill. However, the analysis is extended to go beyond the two extreme scenarios: subsidies without taxes and taxes without subsidies. Different combinations of both instruments are suggested and they are assessed based on their performance regarding economic efficiency, environmental effectiveness and political feasibility.

Keywords: Energy efficiency rebates, deadweight losses, rebound effect

Cite as: Galarraga,I., Abadie, L.M., Ansuategi, A. (2012), Economic efficiency, environmental effectiveness and political feasibility of energy efficiency rebates: the case of the Spanish energy efficiency "Renove" Plan, BC3 Working Paper Series 2013-05. Basque Centre for Climate Change (BC3). Bilbao, Spain

*Basque Centre for Climate Change (BC3). Alameda Urquijo 4, 4º 1ª, Bilbao 48008 (Spain). Tel: +34 94 401 46 90. Fax: +34 94 405 47 87. Corresponding author: ibon.galarraga@bc3research.org
º University of the Basque Country (UPV-EHU). Av. Lehendakari Aguirre, 83, 48015 Bilbao, Spain

**Acknowledgements:**

Ibon Galarraga acknowledges the support of the Fundación Ramón Areces under the project PAEE (Políticas de apoyo a la eficiencia energética: impuestos *vs* subvenciones) and the "Ministerio de Economía y Competitividad" under the project COBELOC (Consumer Behaviour for a Low Carbon Economy, ref. ECO2010-21264).

Alberto Ansuategi and Luis M. Abadie also gratefully aknowledge the support of the Spanish Ministry of Science and Innovation through the research project ECO2011-25064.

The three authors also wish to thank the REPSOL Foundation for the support through the Low Carbon Programme (www.lowcarbonprogramme.org) under which this work has been developed.

## 1. Introduction

Since the energy crisis of the 1970s, OECD countries have enacted a wide array of policies to encourage energy efficiency (Geller *et al*., 2006). These policies include measures such as minimum energy efficiency standards for energy appliances, building codes that encourage energy efficiency, subsidized energy audits, energy efficiency information provision and subsidies for energy efficient appliances and other capital investments. The rationale behind these policies has been to address what is popularly called an *"energy efficiency gap",* the failure of private agents to undertake privately profitable investments in energy efficiency (Jaffe and Stavins, 1994). However, recently some authors have argued that *"when one tallies up the available empirical evidence from different contexts, it is difficult to substantiate claims of a pervasive energy efficiency gap"* (Allcott and Greenstone, 2012). This means that energy efficiency rebates may have introduced distortions to consumers not subject to (investment) inefficiencies and therefore may have led to economic efficiency losses, meaning that the cost of those subsidies may have exceeded the gains in consumers' and producers' surpluses.

But investment inefficiencies are not the only market failure energy efficiency rebates are meant to deal with. Given the risk of serious climate change impacts associated with energy use, since the early 1990s most industrialised nations have also been urged to implement climate-change related policies with the objective of reducing significantly greenhouse gas (GHG) emissions at the lowest possible cost. Some of these climate-change related policies have consisted of investment subsidies to energy efficient durables. Even though neoclassical models of rational consumer choice prescribe Pigovian taxation of carbon emissions as the first-best means of dealing with such externalities, recently some authors have argued that, when some consumers are inattentive to energy costs, subsidies that reduce the relative price of energy efficient durable goods may play a complementary role in defining optimal economic and environmental policy (Allcott et al., 2012). However, the environmental effectiveness of such measures is also called into question, since it has been found that energy efficiency rebates may have had, in some circumstances, a "rebound effect" (Sorrell et al., 2009), that is, they may have increased energy consumption rather than reduce it.

A third element to be taken into account when designing a policy instrument such as an energy efficiency rebate system is its political feasibility. Recently the global financial crisis has led to a change in the role and scope of the government in the economy in general and for environmental policy in particular. The recent state expansion in the form of coordinated fiscal stimulus from G-20 nations is intended to be temporary and weak public balance sheets announce severe cuts in spending over the next few years. It is clear that environmental policy instruments to be implemented in the near future will require substantial capacity to generate government revenue or at least should have limited impact in public spending.

This paper explores these three principles for policy design of energy efficiency rebates (namely, “economic efficiency”, “environmental effectiveness” and “political feasibility”) and illustrates its application to the improved design of the Spanish “Renove” program for energy efficient dishwashers. The program is part of the Spanish Energy Saving and Efficiency Action Plan that sets a minimum of 50 euro as a lump-sum subsidy to consumers (both public or private) willing to purchase the most energy-efficient durables, i.e. labelled as class A+.

The paper is organised as follows, section 2 shows the model to understand and analyse the market for goods that are close substitutes and the effect of the rebates on them. Section 3 deals with the principles for policy design of energy efficiency rebates (economic efficiency, environmental effectiveness and political feasibility) while Section 4 illustrates the analysis with the Spanish “Renove” plan for dishwashers. The final section offers some concluding remarks.

## 2. Three principles for policy design of energy efficiency rebates

It is beyond the scope of this paper to provide a thorough discussion on the rationale for public policies promoting energy efficiency. Three are the main reasons offered by the literature: (1) existence of market failures, (2) presence of high transaction costs and (3) lack of consistently economically rational behaviour of private economic agent (Gillingham *et al.*, 2009).

Our starting point is going to be that, once policymakers have decided to implement a program of energy efficiency rebates, we have to design it in such a way that it should somehow make economic, environmental and political sense.

### 2.1. Economic efficiency

From an economic perspective, energy efficiency rebates fundamentally involve financial incentives for energy efficiency investments. These programs are broadly motivated by the concerns about the perceived underinvestment in energy efficiency. However, when analysing the empirical evidence on whether consumers (and firms) leave profitable energy efficiency investments on the table, the literature is far from conclusive. Allcott and Greenstone (2012) provide an extensive discussion on the weaknesses of existing evidence on returns to energy efficiency investments to support the hypothesis of the presence of an energy efficiency gap. Should this be true and, therefore, should not be a significant wedge between the privately profitable level of investment in energy efficient capital stock and the level that would actually be chosen by private agents in a market without government intervention, then energy efficiency rebates would lead to inefficiency losses (deadweight losses) that should be minimised.

### 2.2. Environmental effectiveness

Energy efficiency rebates could also be considered second-best responses to energy-related environmental externalities such as climate change[1]. In fact, much of the literature on climate policy instruments underlies the key role of "no-regret" measures such as those incentivising energy efficiency improvements. Nevertheless, policies to directly promote energy efficiency may not provide an incentive for reducing consumption of energy services. In fact, energy efficiency improvements decrease the marginal cost of energy services, thereby increasing demand and inducing less-than-proportional reductions in energy use. Therefore, the energy efficiency rebate system should be designed in such a way as to avoid the so-called "rebound effect" in energy consumption.

### 2.3. Political feasibility

Subsidies appear easier to accept both socially and politically than taxes, but must be funded. Governments are currently committed to necessary reductions in other expenses to balance budgets and the costs of extra funding. Budget concerns thus call for revenue-neutral instruments. This means that for an energy efficiency rebate systems to be acceptable in the current political context of fiscal consolidation it should somehow balance funding required to subsidise investments in energy efficient durables and revenues obtained from taxing energy inefficient durables.

## 3. The model

### 3.1. The market for durables

Let us consider the market for two close substitutes: "energy efficiency (EE) labelled durables" and "other durables". The iso-elastic demand functions for EE labelled durables ( $X_L^D$ ) and other durables ( $X_O^D$ ) are given by:

$$X_L^D = AP_L^{\mu_{LL}} P_O^{\mu_{LO}} M^{\eta_L} \quad (1)$$

[1] Energy efficiency rebates do not discriminate among the emissions intensities of different energy sources and thus are less suited to address climatic external effects than other policy instruments such as carbon pricing.

$$X_O^D = A' P_L^{\mu_{OL}} P_O^{\mu_{OO}} M^{\eta_O} \quad (2)$$

where $A$ and $A'$ are positive constants, $P_i$ is the price for EE labelled durables ($i = L$) and for other durables ($i = O$), $M$ is income, $\mu_{ii}$ is the own price demand elasticity for EE labelled durables ($i = L$) and for other durables ($i = O$), $\mu_{ij}$ is the cross price demand elasticity for EE labelled durables ($i = L, j = O$) and for other durables ($i = O, j = L$), and $\eta_i$ is the income elasticity for EE labelled durables ($i = L$) and for other durables ($i = O$).

Let us also consider that the iso-elastic supply functions for EE labelled durables ($X_L^S$) and other durables ($X_O^S$) are given by:

$$X_L^S = B P_L^{\varepsilon_{LL}} P_O^{\varepsilon_{LO}} \quad (3)$$

$$X_O^S = B' P_L^{\varepsilon_{OL}} P_O^{\varepsilon_{OO}} \quad (4)$$

where $B$ and $B'$ are positive constants, $\varepsilon_{ii}$ is the own price supply elasticity for EE labelled durables ($i = L$) and for other durables ($i = O$) and $\varepsilon_{ij}$ is the cross price supply elasticity for EE labelled durables ($i = L, j = O$) and for other durables ($i = O, j = L$).

Without government intervention the market for durables reaches an equilibrium at prices $P_L^*$ and $P_O^*$ so that $X_L^D\left(P_L^*, P_O^*\right) = X_L^S\left(P_L^*, P_O^*\right)$ and $X_O^D\left(P_L^*, P_O^*\right) = X_O^S\left(P_L^*, P_O^*\right)$.

### 3.2. A subsidy for EE labelled durables and a tax for other durables

The policy options considered by the government are to establish a subsidy for EE labelled durables and/or a tax for other durables. This will be reflected in a change in the supply functions for EE labelled durables ($X_L^S$) and other durables ($X_O^S$) that now will be represented by:

$$X_L^S = B\left[P_L\left(1 - s\right)\right]^{\varepsilon_{LL}} \left[P_O(1 + t)\right]^{\varepsilon_{LO}} \quad (5)$$

$$X_O^S = B'\left[P_L(1 - s)\right]^{\varepsilon_{OL}} \left[P_O\left(1 + t\right)\right]^{\varepsilon_{OO}} \quad (6)$$

By taking logarithms and differentiating equations 1, 2, 5 and 6 we can obtain the following system of equations:

$$\frac{dX_L^D}{X_L^D} = \frac{dA}{A} + \mu_{LL}\frac{dP_L}{P_L} + \mu_{LO}\frac{dP_O}{P_O} + \eta_L\frac{dM}{M} \quad (7)$$

$$\frac{dX_O^D}{X_O^D} = \frac{dA'}{A'} + \mu_{OL}\frac{dP_L}{P_L} + \mu_{OO}\frac{dP_O}{P_O} + \eta_O\frac{dM}{M} \quad (8)$$

$$\frac{dX_L^S}{X_L^S} = \frac{dB}{B} + \varepsilon_{LL}\frac{dP_L}{P_L} + \varepsilon_{LL}\frac{d\sigma}{\sigma} + \varepsilon_{LO}\frac{dP_O}{P_O} + +\varepsilon_{LO}\frac{d\tau}{\tau} \quad (9)$$

$$\frac{dX_O^S}{X_O^S} = \frac{dB'}{B'} + \varepsilon_{OL}\frac{dP_L}{P_L} + \varepsilon_{OL}\frac{d\sigma}{\sigma} + \varepsilon_{OO}\frac{dP_O}{P_O} + +\varepsilon_{OO}\frac{d\tau}{\tau} \quad (10)$$

where $\tau = 1 + t$ and $\sigma = 1 - s$.

Given that $A$, $A'$, $B$ and $B'$ are assumed to be constant parameters that will not be affected by the policy, we have that:

$$\frac{dA}{A} = \frac{dA'}{A'} = \frac{dB}{B} = \frac{dB'}{B'} = 0 \quad (11)$$

We can also approximate the change in income due to the tax and/or subsidy as the quantity consumed of each good times the price change originated with the tax and/or subsidy:

$$\frac{dM}{M} = -w_L\frac{dP_L}{P_L} - w_O\frac{dP_O}{P_O} \quad (12)$$

where $w_L = \frac{P_L X_L}{M}$ and $w_O = \frac{P_O X_O}{M}$ stand for the expenditure share for EE labelled durables and other durables, respectively.

Equations (7)-(12) give a system of equations that can be solved by substituting the values of the different elasticities, taxes and subsidies. The new equilibrium state (and the deadweight loss) are calculated through nested interactions of an inner and outer loop. The outer loop (first) iterating through the two market segments, and the inner loop (second) through the shifts in supply, one at a time. The shifts have been decomposed into a sufficiently high number of equal intervals. Thus, after every iteration of the inner loop, new equilibrium prices and quantities are calculated. By decomposing the supply shifts, the error arising from making a linear extrapolation across a non-linear interval is reduced. The systems is solved for each different expenditure share ( $w_L$ and $w_O$ ) and introducing the supply shifts one at a time. This means that with every new equilibrium price and quantity, new expenditure shares are calculated.

With regard to the deadweight loss (DWL), it can be approximated in line with the analysis presented in Diamond & McFadden (1974)[2] as:

$$DWL = (X_L^1 - X_L^0) * dP_L * 0.5 - (X_O^1 - X_O^0) * dP_O \quad (13)$$

where $X_L^0$ and $X_L^1$ are the quantities of EE labelled durables before and after the introduction of the subsidy, respectively; and $X_O^0$ and $X_O^1$ are the quantities of other durables before and after the introduction of the tax, respectively. Note that the price differential in this equation refers to the price change derived directly from the tax or subsidy, not to the change in equilibrium price.

# 4. The Spanish "Renove" plan for dishwashers: a numerical illustration

In this section we complement the analysis with (1) the calculus of efficiency losses, impact on energy consumption and cost for public finance of the Spanish "Renove" plan for dishwashers as it is currently designed and (2) a detailed simulation of alternative designs in order to improve the economic efficiency, environmental effectiveness and political feasibility of such plan.

## 4.1. Setup

The Spanish "Renove" Plan for Domestic Appliances is a public initiative launched by the central government in Spain that promotes the replacement of old appliances by new energy

[2] Note that this definition of the DWL is equivalent to the one in Stern (1987). The equations are the same for the cases in which the income effect is not significant, and, thus, the uncompensated and compensated responses are equal. For further discussion on the issue see Albi *et al* (2000).

efficient ones (labelled as class A+) with a rebate to the final consumer. The Spanish Ministry of Industry transfers financial resources to regional governments and these governments are those who organise and manage the "Renove" plan in each region. In this analysis we will focus on the Renove Plan for dishwashers implemented in year 2009 by the Basque Government under the umbrella of the Spanish "Renove" Plan for Domestic Appliances.

In order to carry out the numerical simulations in the paper we require values for: (1) own-, cross-price and income elasticities, (2) supply elasticities and (3) initial equilibrium price and quantities. Estimates of demand elasticities as well as quantities and prices come from Galarraga et al. (2011) and are presented in Table 1. Estimating supply elasticities is very much outside the scope of this paper. Therefore, we use some "well-guesed" values, presented in Table 2.

**Table 1: Original Quantities and Prices of the Market Segments**

| Product | Original Quantities (Units) | Original average Prices (Euro) | Own price elasticity of demand ($\mu_{ii}$) | Cross price elasticity of demand ($\mu_{ij}$) | Income elasticity ($\mu_i$) |
|---|---|---|---|---|---|
| Non-labelled dishwashers (good 1) (60%) | $x_2^0 = 21{,}355$ | $P_2^0 = 514$ | -0.5 | 0.10 | 0.4 |
| A+ Labelled dishwashers (good 2) (40%) | $x_1^0 = 12{,}325$ | $P_2^0 = 514 + 80 = 594$ | 0.55 | 0.15 | 0.4 |

**Source:** Galarraga et al. (2011).

**Table 2: Supply-side Elasticity Estimates**

| Own price elasticity of supply non-labelled dishwashers (good 1) | Own price elasticity of supply labelled dishwashers (good 2) | Cross pirce elasticities of supply |
|---|---|---|
| $\varepsilon_{LL}$=1.5 | $\varepsilon_{OO}$=1.2 | $\varepsilon_{OL}$= $\varepsilon_{LO}$=0 |

**Source:** Own elaboration.

### 4.2. Economic efficiency, environmental effectiveness and political feasibility of the current system of energy efficiency rebates

Here we will start analysing the economic efficiency, environmental effectiveness and political feasibility of the current system of energy efficiency rebates in the Basque Autonomous Community (BAC) of Spain. The programme is part of the Energy Savings and Efficiency Action Plan, regulated by Royal Decree 208/2005, 25th February 2005, on electrical appliances and electronic devices and the management of their wastes. The Programme sets a minimum of €50 as a lump sum subsidy for consumers (both public or private) willing to purchase highly efficient durables, i.e. labelled as class A or higher. As the programme is run by the Government of each of the Autonomous Communities, the amount of the subsidy varies depending on the region analysed. In the case of the BAC the subsidy for EE labelled dishwashers is 80 €. The main findings are summarised in Table 3.

When EE labelled dishwashers are subsidized with 80 € the demanded quantities of labelled dishwashers increases by 5.1% as a consequence of the shift in supply. This originates a reduction on the demand of non-labelled ones of 0.7%. The new equilibrium prices will also change, both decreasing by 8.9% on the labelled market segment and by 0.5% on the other ones.

The policy will have a subsidy cost of more than 1 M€ while it will generate a welfare loss close to 26,000 €. Thus the net effect will be then a cost of 1.063 M€. As a consequence of the subsidy the total number of demanded dishwashers in the market will increase by 1.5% (from 33,680 to 34,169 units) which at the end of the day generates a rebound effect in terms of increased energy consumption, generating an increase of 197,399 € in the total energy bill[3].

[3] This is calculated with the figures on the average energy consumption in 10 years (kWh) and average total costs reported in Galarraga et al. (2011).

**Table 3: Results of a 80 € subsidy**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 12,961.28 | 541.39 | 5.16 | -8.86 | Subsidy Cost | 25,800.95 | -272,962.41 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 21,207.42 | 511.63 | -0.69 | -0.46 | -1,036,902.08 | | 75,562.80 |
| **Total** | **33,680** | **-** | **34,168.69** | | | | | | **-197,399.61** |

### 4.3. Other alternatives to design an energy efficiency rebate system

In the following section we analyse different policy alternatives that can be calculated to improve the design of the system. The first alternative we propose would be taxing "the bads", that is it, to put a tax on non-efficient appliances (see Table 4). In this case, and assuming that a 40€ tax is imposed, the number of labelled dishwashers would increase in 0.6% as a consequence of the cross effect while the demand of non-labelled appliances would decrease in almost 3% as a consequence of a 6% price increase. This policy will generate a welfare loss of 12,000€ while collecting almost 1M€ and generating no rebound effect with a saving in the energy bill of almost 300,000€.

Thus, it seems that according to the three principles mentioned above taxing non-labelled goods would be better than subsidising labelled goods. But subsidies appear easier to accept both socially and politically than taxes and it may be noted that we should take into account more scenarios than "subsidies without taxes" or "taxes without subsidies".

Having this in mind it is possible to look for policy alternatives that combine both taxes and subsidies that could lead to more desirable outcomes. With this purpose we have constructed and represented various functions aligned with the three principles (see Figure 1). This has been done as follows:

- For **economic efficiency** we have focussed in policy alternatives that generate a similar DWL as the existing. The representation of the function allows us to explore options that generate lower or higher welfare losses. (See Figure 2).
- The function for **environmental effectiveness** is represented by all those policy combinations that do not increase the energy bill.
- And finally, **political feasibility** is represented by the line that comprises all the combinations of taxes and subsidies that generate zero deficit.

This representation significantly simplifies the analysis as any policy maker can deduct the potential impacts of the policy option that is considering.

Let us illustrate the use of the figure by adequately selecting seven points (from 1 to 7) to represent all the possible combinations of the three principles. The results are gathered in subsequent tables.

**Table 4: Results of a 40 € tax**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 12,399.30 | 596.98 | 0.60 | 0.50 | Collected 829,928.16 | 12,357.53 | -31,875.41 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,748.20 | 545.02 | -2.84 | 6.04 | | | 310,679.54 |
| **Total** | **33,680** | | **33,147.51** | | | | | | **278,804.14** |

**Figure 1: The three principles of policy design**

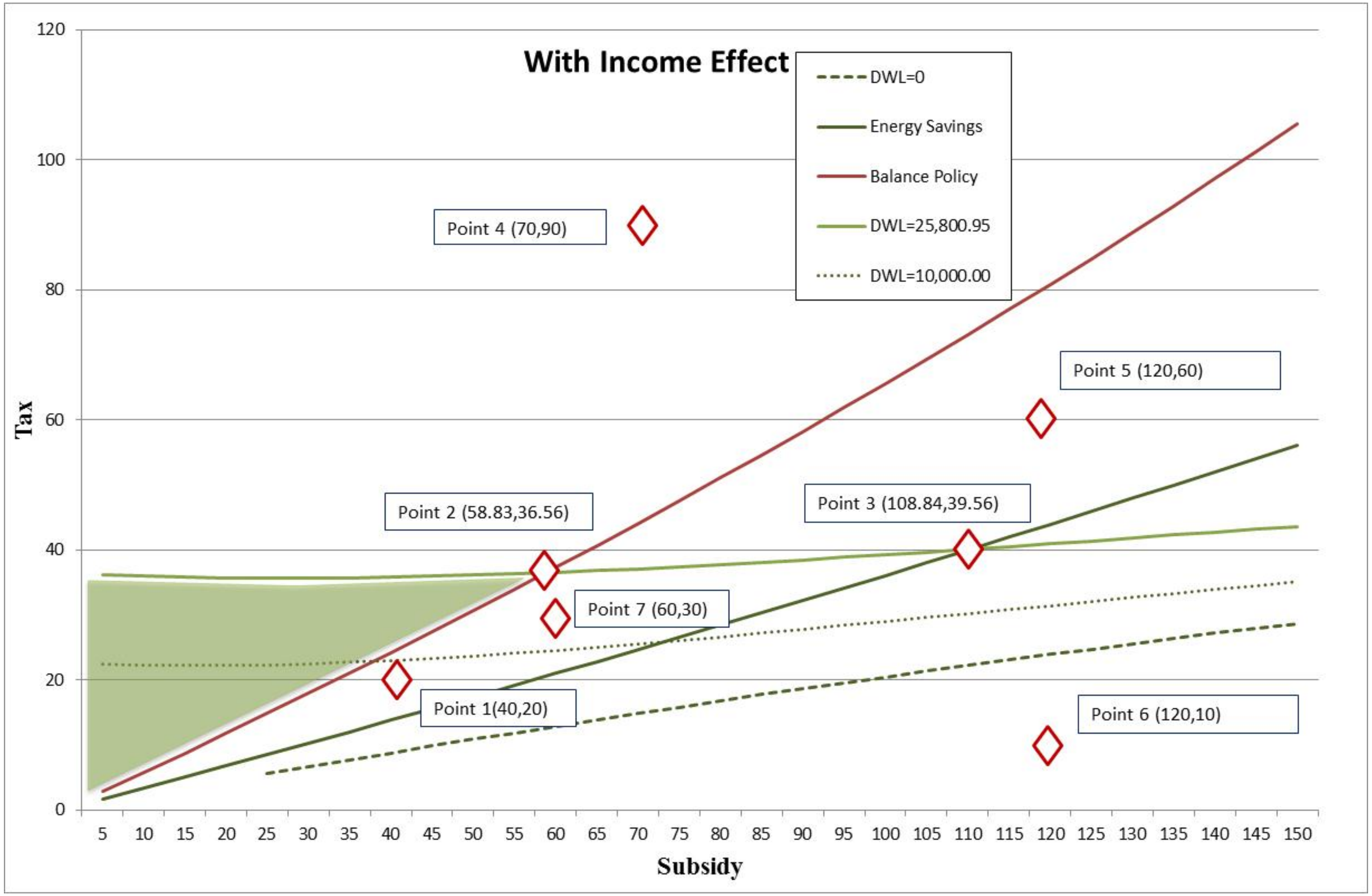
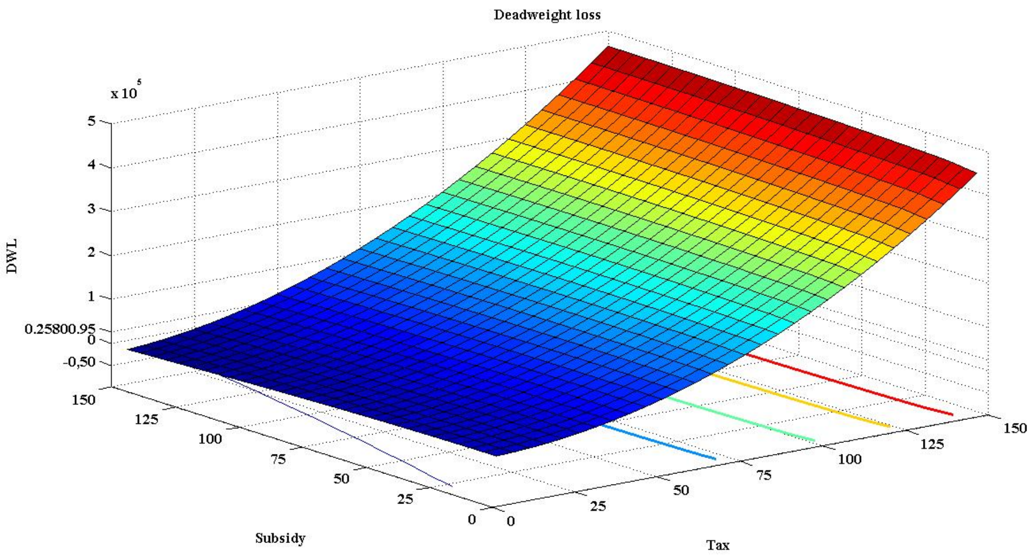


**Figure 2: Taxes, Subsidies and DWL**



1 The following results are obtained for the two points:

- **Point 1: A Subsidy of 40€ and a tax of 20€:** The specific results are shown in Table 5. This point implies some progress with regard to the three requirements explained before (namely economic efficiency, environmental effectiveness and political feasibility). That is it, the DWL is lower than the one generated by the "subsidy with not taxes" and even lower that the DWL generated by the "tax with no subsidy", there is no rebound effect and thus some energy saving is possible, and finally it generates no deficit. Therefore, the policies within this green triangle are the ones that comply with the three objectives.

2 Other options (points in the figure) that do not comply with one or several of the three principles are analysed below with illustrative purposes. These combinations of policies are:

- **Point 2 (a subsidy of 58.83€ and a tax of 36.56€)** in Table 6 and **Point 4 (a subsidy of 70€ and a tax of 90€)** in Table 8 that generate some energy saving while they create no deficit with a DWL not lower than the Renove rebate.

- **Point 3 (a subsidy of 108.84€ and a tax of 39.56€)** in Table 7 and **Point 5 (a subsidy of 120€ and a tax of 60€)** in Table 9 that generate some deficit, not lower DWL than the rebates but also no significant increase in energy bill (some savings for the case of point 5).

- **Point 6 (a subsidy of 120€ and a tax of 10€)** in Table 10 that although generates lower DWL than rebates, it creates a rebound effect (increases energy bill) and also generates some deficit for the Government.

- **Point 7(a subsidy of 60€ and a tax of 30€)** in Table 11 that although it generates a lower DWL and contributes to energy savings, generates a deficit for the Government.

**Table 5: Results of a 40 € subsidy and 20€ tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 12,677.18 | 568.51 | 2.86 | -4.29 | Collected | -3,470.99 | -151,083.16 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,976.55 | 528.06 | -1.77 | 2.74 | -87,555.94 | | 193,764.54 |
| **Total** | **33,680** | | **33,653.73** | | | | | | **42,681.38** |

**Table 6: Results of a 58.83 € subsidy and 36.56 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 12,858.05 | 557.56 | 4.32 | -6.13 | Collected | 25,806.40 | -228,679.87 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,694.38 | 540.45 | -3.09 | 5.15 | 147.32 | | 338,236.59 |
| **Total** | **33,680** | **-** | **33,552.43** | | | | | | **109,556.72** |

**Table 7: Results of a 108.84 € subsidy and 39.56 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 13,272.82 | 526.52 | 7.69 | -11.36 | Collected | 24,990.56 | -406,614.84 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,560.84 | 541.27 | -3.72 | 5.31 | -631,226.83 | | 406,608.87 |
| **Total** | **33,680** | **-** | **33,833.66** | | | | | | **-5.97** |

**Table 8: Results of a 70 € subsidy and 90 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 13,048.90 | 554.42 | 5.87 | -6.66 | Collected | 164,831.11 | -310,553.94 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 19,894.17 | 584.11 | -6.84 | 13.64 | 877,052.37 | | 747,943.80 |
| **Total** | **33,680** | **-** | **32,943.07** | | | | | | **437,389.86** |

**Table 9: Results of a 120 € subsidy and 60 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 13,404.42 | 521.30 | 8.76 | -12.24 | Collected | 68,022.67 | -463,073.24 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,241.24 | 557.38 | -5.22 | 8.44 | -394,056.69 | | 570,246.10 |
| **Total** | **33,680** | **-** | **33,645.66** | | | | | | **107,172.86** |

**Table 10: Results of a 120 € subsidy and 10 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 13,310.36 | 517.60 | 7.99 | -12.86 | Collected | -12,811.26 | -422,718.30 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,982.52 | 517.99 | -1.74 | 0.78 | -1,387,417.63 | | 190,707.31 |
| **Total** | **33,680** | **-** | **34,292.88** | | | | | | **-232,010.99** |

**Table 11: Results of a 60 € subsidy and 30 € tax (with income effect)**

| Market Segment | Original Quantities | Original Prices (€) | After Policy Quantities | After Policy Prices | Change in Quant. (%) | Change in Prices (%) | Balance of the policy (€) | Welfare loss (€) | Energy savings (€) |
|---|---|---|---|---|---|---|---|---|---|
| **A+ Labelled dishwashers (40%)** | 12,325 | 594 | 12,855.20 | 556.32 | 4.30 | -6.34 | Collected | 16,397.10 | -227,455.32 |
| **Non-labelled dishwashers (60%)** | 21,355 | 514 | 20,790.26 | 535.24 | -2.64 | 4.13 | -147,604.18 | | 289,147.71 |
| **Total** | **33,680** | **-** | **33,645.46** | | | | | | **61,692.39** |

## 5. Conclusions

There are many situations in which decision makers need to have information on the potential effect of the policies that have to be implemented. The methodology proposed in this paper offers a relatively simple way to carry out a detailed ad hoc analysis of the policy proposals contributing to the policy design phase. We have illustrated this with the case of energy efficiency labels and some of the policies that can be used to promote its use, the so-called rebates. With this purpose we have used the market data collected in Galarraga et al. (2011) and the demand elasticity values calculated for dishwashers in Spain. Three alternative market based instruments have been studied: a tax, a subsidy and a combination of both. The use of subsidies (rebates) to promote the purchase of energy efficient household appliances in Spain is very common and has been used for many years. Therefore, the paper has set off by analysing the impact of these subsidies of 80€ and found that as a consequence of the policy the total number of dishwashers at the market increases in 1.5%. The labelled ones increase a 5% while the quantity of non-labelled ones by 0.7%. The policy has a net subsidy cost of 1 M € euro and as a consequence of the increase in the number of appliances there is an increase in the energy bill of 197,400€. This can interpreted as the cost of the rebound effect.

If instead a tax of 40€ is implemented on non efficient appliances, the final outcome differs. In this case the total number of appliances will be reduced by 1.6% (and no rebound effect will be expected for this reason generating significant energy saving) while collecting 0.8 M€. When all cross effects are taken into account the equilibrium price will be 6% higher for non-labelled dishwashers (with a nearly 3% decrease in demanded quantities) and 0.5% for labelled ones (with a 0.6% increase in quantities).

The analysis is extended in order to take into account more scenarios than just the “subsidies without taxes” or “taxes without subsidies” alternatives. The paper proposes three policy principles that could be used to assess different policy alternatives. These are: economic efficiency, environmental effectiveness and political feasibility. The principles have been used to illustrate several policy options showing the combinations of taxes and subsidies that can improve the outcome of the rebates scheme. The combination of tax and subsidies can be justified in terms of ethical beliefs, as the users of non-efficient appliances should be the ones compensating the consumers that opt for efficient appliances instead of all society.

The analysis shows that in our case the DWL increases as we increase the tax with very much lower sensitivity to the level of subsidies. This means that if we want to minimise efficiency losses the tax on non-labelled goods should not exceed 36€ (see Figure 2).

Of course many other policy restrictions or principles could also be tested. This paper is only illustrative of the kind of analysis that could be done with the methodology proposed in the paper when both own and cross price elasticities are available.

## 6. References

Allcott, H. and M. Greenstone (2012), Is There an Energy Efficiency Gap?, WP 12-03, MIT-Department of Economics Working Paper Series.

Ansuategi, A. and Galarraga, I. (2009), Carbon Pricing as an Effective Instrument of Climate Policy: Searching for an Optimal Policy Instrument. *Rivista di Politica Economica*, VII-IX.

Bovenberg, A. L. and Goulder, L. H. (2002), Environmental Taxation and Regulation in Auerbach, A. and Feldstein, M. (eds): Handbook of Public Economics, vol. 3 Elsevier Science, North-Holland.

Greening, L.A., Greene, D.L., Difiglio, C., (2000), Energy efficiency and consumption – the rebound effect – a survey. *Energy Policy* 28 (6–7), 389–401.

Diamond, P.A. and McFadden, D.L. (1974). Some Uses of the Expenditure Function in Public Finance. *Journal of Public Economics*, 3:3-21.

Ellerman, D. and B. K. Buchner (2007), The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results, *Review of Environmental Economics and Policy* 1, 66-87.

Galarraga, I. and Abadie, L.M. (2011). Ecolabels. Encyclopedia of Sustainability, titled Measurements, Indicators, and Research Methods for Sustainability. US. BERKSHIRE PUBLISHING GROUP.

Galarraga, I, González-Eguino, M. and Markandya, A. (2011), Willingness to pay and price elasticities of demand for energy-efficient appliances: combining the hedonic approach and demand systems. *Energy Economics*, vol 33: 66-74

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 Naturales*, Vol. 4(7).

Galarraga, I. and Markandya, A. (2003), The analysis of welfare effects of an environmental product tax: an application to the taxation of car tyres in Hungary. *Fiscal Studies*, 24 (1).

Geller, H., P. Harrington, A. H. Rosenfeld, S. Tanishima and F. Unander (2006), Policies for Increasing Energy Efficiency: Thirty Years of Experience in OECD Countries, *Energy Policy* 34: 556-573.

Green, K. P., Hayward, S. F. and Hassett, K. A. (2007), Climate Change: Cap Vs. Taxes, Environmental Policy Outlook, American Enterprise Institute for Public Policy Research, *AEI*, nº 2, June.

Goulder, L. H. (2009), Carbon Taxes Versus Cap and Trade. Working paper, Department of Economics, Stanford University.

Morris, G. E. and Kis, A. (1996), The Design and Assessment of an Environmental Product Charge on Tires in Hungary. Report prepared by the Harvard Institute for International Development.

Newell, R. G. And Pizer, W. A. (2003), Regulating stock externalities under uncertainty, *Journal of Environmental Economics and Management* 45: 416–432.

Nordhaus, W. D. (2006), After Kyoto: Alternative Mechanisms to Control Global Warming, *AEA* Papers and Procedings, vol. 96 n2.

OECD (1996), Implementation Strategies for Environmental Taxes. OCDE, Paris.

OECD (2004), The United Kingdom Climate Change Levy: A Study in Political Economy", COM/ENV/EPOC/CTPA/CFA (2004)66/FINAL.

Parry, I. and Pizer, B. (2007), Combating global warming: is taxation or cap-and-trade the better strategy for reducing greenhouse emissions, *Regulation* 30 (3).

Portney, P.(2003), Market-based approaches to environmental policy. *Resources for the future, WDC*, *Resources* (Summer) (2003), pp. 15–18.

Rosen, H. S. (1984), Public Finance, Spanish edition, Ariel Economía.

Sorrell, S., J. Dimitropolous and M. Sommerville (2009), Empirical Estimates of Direct Rebound Effects: A Review, *Energy Policy* 37: 1356-1371.

Stavins R. N. (2005), Experience with market-based environmental policy instruments. In John F. Kennedy School of Government, Harvard University, Cambridge, MA and Resources for the Future, Washington, DC, USA

World Bank (2005) Environmental Fiscal Reform: What Should be Done and How to Achieve It, The World Bank, Washington DC.

# BC3 WORKING PAPER SERIES

## Basque Centre for Climate Change (BC3), Bilbao, Spain

The BC3 Working Paper Series is available on the internet at the following addresses:

http://www.bc3research.org/lits_publications.html

http://ideas.repec.org/s/bcc/wpaper.html

| | |
|---|---|
| 2012-07 | Ferdinando Villa, Ken Bagstad, Gary Johnson, Brian Voigt: *Towards a Comprehensive Approach to Quantifying and Mapping Ecosystem Services* |
| 2012-08 | Roger Fouquet: *Economics of Energy and Climate Change: Origins, Developments and Growth* |
| 2012-09 | Maria-Angeles Diez, Iker Etxano, Eneko Garmendia: *Evaluating Governance and Participatory Processes in Natura 2000: Lessons Learned and Guidance for Future Prospects* |
| 2012-10 | Iker Etxano, Eneko Garmendia, Unai Pascual. David Hoyos, Maria-Angeles Diez, José A. Cadiñanos, Pedro J. Lozano: *Towards a Participatory Integrated Assessment Approach for Planning and Managing Natura 2000 Network Sites* |
| 2012-11 | Luis M. Abadie and José M. Chamorro: *Valuation of Wind Energy Projects: A Real Options Approach* |
| 2012-12 | Helen Ding and Paulo A.L.D. Nunes: *Modeling the Links between Biodiversity, Ecosystem Services and Human Wellbeing in the context of Climate Change: Results from an Econometric Analysis on the European Forest Ecosystems* |
| 2012-13 | Helen Ding, Anil Markandya and Paulo A.L.D. Nunes: *The Economic Impacts of Biodiversity Policy for Improving the Climate Regulating Services Provided by EU Natura 2000 Habitats* |
| 2012-14 | Martin-Ortega, J. E. Ojea, C. Roux. *Payments for Water Ecosystem Services in Latin America: Evidence from Reported Experience.* |
| 2013-01 | Samuel Bobbino, Héctor Galván and Mikel González-Eguino: *Budget-Neutral Financing to Unlock Energy Savings Potential: An Analysis of the ESCO Model in Barcelona* |
| 2013-02 | Agustin del Prado, Karlos Mas, Guillermo Pardo, Patricia Gallejones: *Development of a new modelling framework to estimate the C footprint from Basque dairy farms* |
| 2013-03 | Roger Fouquet: *Long Run Demand for Energy Services: the Role of Economic and Technological Development* |
| 2013-04 | David Heres, Steffen Kallbekken and Ibon Galarraga: *Understanding Public Support for Externality-Correcting Taxes and Subsidies: A Lab Experiment* |
| 2013-05 | Ibon Galarraga, Luis María Abadie and Alberto Ansuategi: *Economic Efficiency, Environmental Effectiveness and Political Feasibility of Energy Efficiency Rebates: the Case of the Spanish Energy Efficiency “Renove” Plan.* |