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The use "Bonus-Malus" schemes for the promotion of Energy efficient household appliances: a case study for Spain

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Overview

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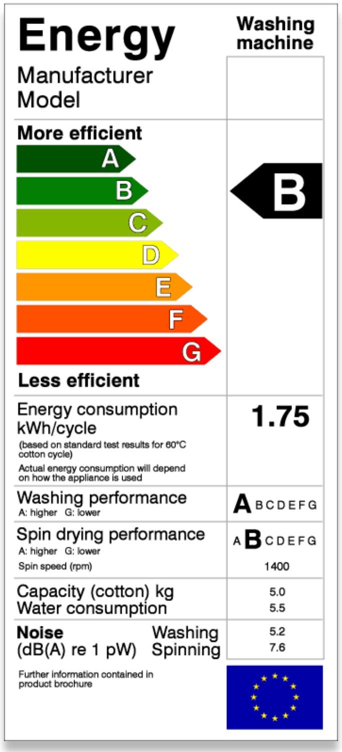
1. Energy Labelling and the RENOVE subsidy scheme

- Energy labelling is acquiring a major importance in the light of the EU Climate and Energy package that sets the target of reducing energy consumption by 20% by 2020.
- The goal of a 27% energy saving in the residential sector (European Council 2006).
- Directive 92/75/ECC regulated information on energy and other resources consumption in household appliances.
- 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.



1. Energy Labelling and the RENOVE subsidy scheme

- In many countries subsidies are used to support labelled goods. The RENOVE program is the Spanish policy.
- Regulated by Royal Decree 208/2005, 25 February 2005, on electrical appliances and electronic devices and the management of their wastes.
- Set up by the Institute for Energy Diversification and Saving (IDAE, Instituto para la Diversificación y el Ahorro Energético) www.idae.es
- But run and managed by the Energy Boards of the Autonomous Communities (AC).
- Sets a minimum of €50 as a lump sum subsidy to consumers (both public or private) willing to purchase (exchange) highly efficient durables, i.e. labelled as class A or higher;
- Some AC have increased this premium to €105 and more.

2. Research idea

- How do policy makers estimate how much is the optimum subsidy? Do they “fine tune” the program each year according to an evaluation?
- How can we measure the impact of the scheme?

- We need to know how much people are willing to pay for those labels. Economic valuation technique. **Question A**.
- And we also need price elasticities of demand (and supply) to properly assess the impact of the policy. How can be estimate them? **Question B**.
- We can measure the impact of the scheme and perhaps propose alternatives. **Question C.**
- **Can we improve the proposal: Question D.**

2. Research idea

- Answer to A and to B in:
  - Galarraga, I, Heres, D. and González-Eguino, M. (2011), “Price premium for high-efficiency refrigerators and calculation of price-elasticities for close-substitutes: Combining Hedonic Pricing and Demand Systems”. ***Journal of Cleaner Production***.
  - Galarraga, I, González-Eguino, M. ... (2011), “Willingness to pay and price elasticities ... ergy-efficient appliances: combining the hedonic approach and ... systems”. ***Energy Economics***, vol 33 pp. 66-74

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- Partial Answer to C in:
  - Galarraga, I., Abadie L.M. ... Efficiency, Effectiveness and Implementation Feasib... Efficiency Rebates: The “Renove” Plan in Spain”. **Energy Econo...ics**, 40(1), S98-S107.

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- Improving earlier approach:
  - Moving from a first appr... exercise!

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3. Bonus Malus schemes in the literature

- The idea in Bonus Malus scheme is taxing the "bads" (inefficient goods) to subsidise the goods (Labelled goods). This should allow to partially finance the subsidy scheme with the taxes significantly reducing the cost of the policy.
- Also known as "Feebates" (a combinations of words resulting from `fee` and `rebate´) (Eilert et al, 2010).
- Some examples:
  - car market in the US (Langer, 2005; Davis et al, 1995 ; Banerjee, 2007),
  - fuel efficiency (Greene et al. 2005),
  - French vehicles based in CO2 emissions (ASE, 2009),
  - food groups (Gustavsen and Rickertsen, 2013; Markandya et al, 2014),
  - fair trade and regular coffee (Galarraga and Markandya, 2006),
  - nitrogen oxide (NOx) in Sweden (Johnson, 2006).
  - energy efficiency in buildings at state level in US (Eilert et al, 2010).

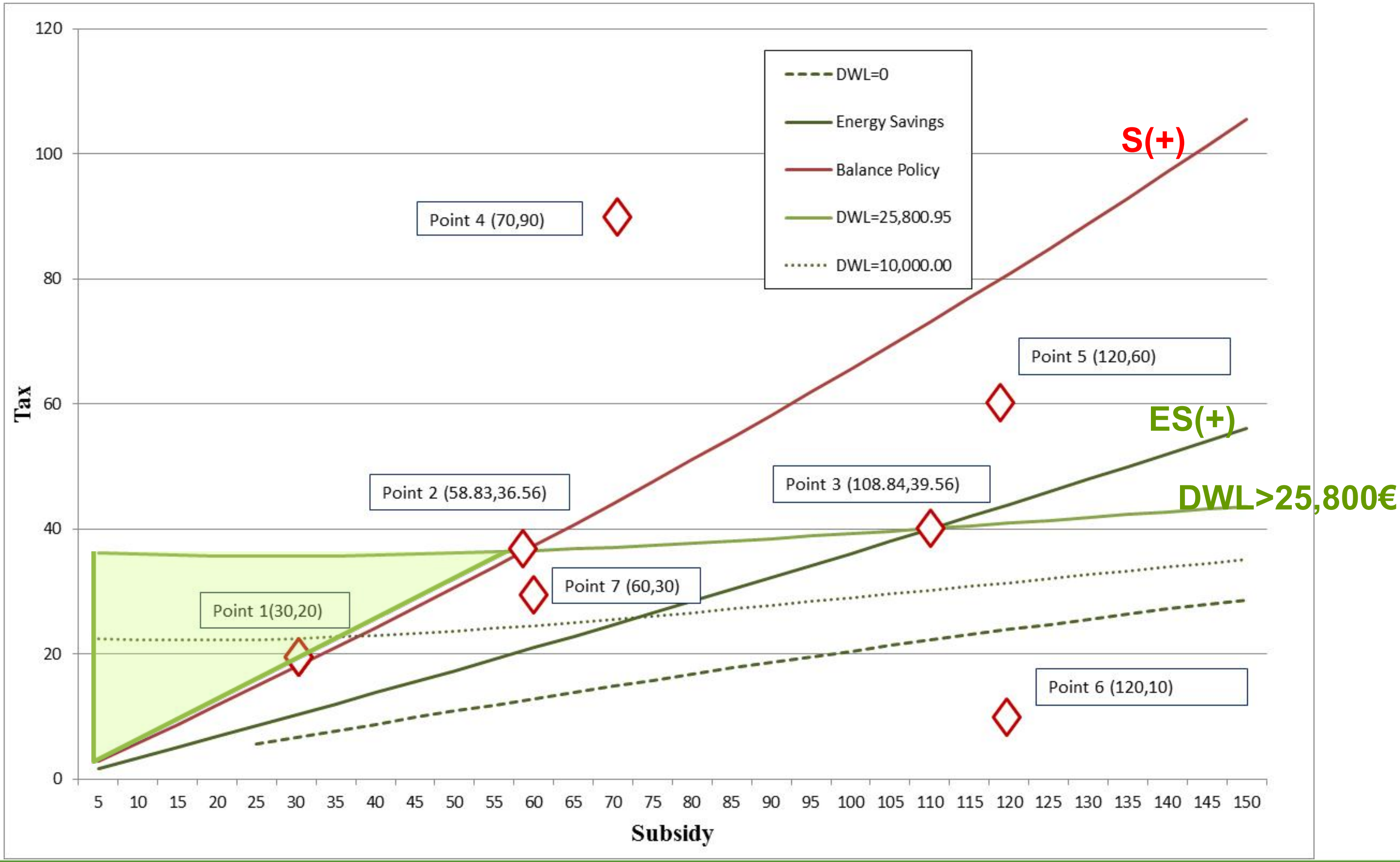
3. Bonus Malus schemes in the literature

- Eilert et al (2010) conclude that feebates can "complement existing efficiency programs by providing greater support to newer, more expensive but highly efficient technologies, as well as by providing a new mechanism to tap into saving potential in hard-to-reach market segments".

- Limited work for the case of energy efficient appliances.
  - Rivers and Peter (2007) for Canadian appliances labelled under Energy star program.
  - Galarraga et al (2013) for the case of Spanish dishwashers carrying the EU energy efficiency label,

3. Bonus Malus schemes in the literature

- Galarraga et al (2013).



4. The Model (I)

We define the following isoelastic demand and supply functions:

$$x_i = P_i^{\mu_{ii}} P_j^{\mu_{ij}} m^{\eta_1} \quad i \neq j \qquad (1)$$

$$x_i = P_i^{\varepsilon_{ii}} P_j^{\varepsilon_{ij}} \quad i \neq j \qquad (2)$$

Where P_i is the price of the goods, m is income, μ_{ii} is the Marshallian (Uncompensated) own price demand elasticity for product i, μ_{ij} is the Marshallian (Uncompensated) cross price demand elasticity, ε_{ii} is the own price supply elasticity for good i, ε_{ij} is the cross price supply elasticity and η_i is the income elasticity of the ith product.

For the Dead Weight Loss (DWL) of the multiple taxes (and subsidies) we use the approximation by Stern (1987) and Tresch (1981),

$$DWL = 0.5 \sum_{i=1}^{i=n} \sum_{j=1}^{j=n} \tau_i \tau_j P_i P_j S_{ij} \qquad (3)$$

Where S_{ij} is the Compensated change in the demand for good “i” when there is a change in the price of good “j”.

4. The Model (II)

Taking logs and differentiating equations (1) and (2), for the n goods case we have the following demand functions,

$$\frac{\Delta q_1}{q_1} = \mu_{11}\frac{\Delta p_1}{p_1} + \mu_{12}\frac{\Delta p_2}{p_2} + \ldots + \mu_{1n}\frac{\Delta p_n}{p_n} + \eta_1\frac{\Delta m}{m} \qquad (4)$$

$$\frac{\Delta q_2}{q_2} = \mu_{21}\frac{\Delta p_1}{p_1} + \mu_{22}\frac{\Delta p_2}{p_2} + \ldots + \mu_{2n}\frac{\Delta p_n}{p_n} + \eta_2\frac{\Delta m}{m} \qquad (5)$$

…

$$\frac{\Delta q_n}{q_n} = \mu_{n1}\frac{\Delta p_1}{p_1} + \mu_{n2}\frac{\Delta p_2}{p_2} + \ldots + \mu_{nn}\frac{\Delta p_n}{p_n} + \eta_n\frac{\Delta m}{m} \qquad (6)$$

and supply functions,

$$\frac{\Delta q_1}{q_1} = \varepsilon_{11}\frac{\Delta p_1}{p_1} + \varepsilon_{12}\frac{\Delta p_2}{p_2} + \ldots + \varepsilon_{1n}\frac{\Delta p_n}{p_n} \qquad (7)$$

$$\frac{\Delta q_2}{q_2} = \varepsilon_{21}\frac{\Delta p_1}{p_1} + \varepsilon_{22}\frac{\Delta p_2}{p_2} + \ldots + \varepsilon_{2n}\frac{\Delta p_n}{p_n} \qquad (8)$$

…

$$\frac{\Delta q_n}{q_n} = \varepsilon_{n1}\frac{\Delta p_1}{p_1} + \varepsilon_{n2}\frac{\Delta p_2}{p_2} + \ldots + \varepsilon_{nn}\frac{\Delta p_n}{p_n} \qquad (9)$$

4. The Model (III)

If we now represent the introduction of a tax (subsidy) as a proportional change in the supply of the product taxed (subsidised), being τ the tax on the good i[1], from equations (7) to (9) the following supply functions emerge;

$$\frac{1}{\varepsilon_{11}}\frac{\Delta q_1}{q_1}-\frac{\Delta p_1}{p_1}-\frac{\varepsilon_{12}}{\varepsilon_{11}}\frac{\Delta p_2}{p_2}-\frac{\varepsilon_{13}}{\varepsilon_{11}}\frac{\Delta p_3}{p_3}-\ldots-\frac{\varepsilon_{1n}}{\varepsilon_{11}}\frac{\Delta p_n}{p_n}=-\frac{\tau_1}{p_1} \qquad (10)$$

$$\frac{1}{\varepsilon_{22}}\frac{\Delta q_2}{q_2}-\frac{\varepsilon_{21}}{\varepsilon_{22}}\frac{\Delta p_1}{p_1}-\frac{\Delta p_2}{p_2}-\frac{\varepsilon_{23}}{\varepsilon_{22}}\frac{\Delta p_3}{p_3}-\ldots-\frac{\varepsilon_{2n}}{\varepsilon_{22}}\frac{\Delta p_n}{p_n}=-\frac{\tau_2}{p_2} \qquad (11)$$

…………..

$$\frac{1}{\varepsilon_{nn}}\frac{\Delta q_n}{q_n}-\frac{\varepsilon_{n1}}{\varepsilon_{nn}}\frac{\Delta p_1}{p_1}-\frac{\varepsilon_{n2}}{\varepsilon_{nn}}\frac{\Delta p_2}{p_2}-\frac{\varepsilon_{n3}}{\varepsilon_{nn}}\frac{\Delta p_3}{p_3}-\ldots-\frac{\varepsilon_{n,n-1}}{\varepsilon_{nn}}\frac{\Delta p_{n-1}}{p_{n-1}}-\frac{\Delta p_n}{p_n}=-\frac{\tau_n}{p_n} \qquad (12)$$

Assuming cross price elasticities of supply equal to zero we have,

$$\frac{1}{\varepsilon_{11}}\frac{\Delta q_1}{q_1}-\frac{\Delta p_1}{p_1}=-\frac{\tau_1}{p_1} \qquad (13)$$

$$\frac{1}{\varepsilon_{22}}\frac{\Delta q_2}{q_2}-\frac{\Delta p_2}{p_2}=-\frac{\tau_2}{p_2} \qquad (14)$$

4. The Model (IV)

So that,

$$\begin{bmatrix} \frac{\Delta q_1}{q_1} \\ \frac{\Delta q_2}{q_2} \end{bmatrix} = \begin{bmatrix} 1-\frac{\mu_{11}-\eta_1 w_1}{\varepsilon_{11}} & -\frac{(\mu_{12}-\eta_1 w_2)}{\varepsilon_{22}} \\ -\frac{\mu_{21}-\eta_2 w_1}{\varepsilon_{11}} & 1-\frac{\mu_{22}-\eta_2 w_2}{\varepsilon_{22}} \end{bmatrix}^{-1} \times \begin{bmatrix} (\mu_{11}-\eta_1 w_1)\frac{\tau_1}{p_1} + (\mu_{12}-\eta_1 w_2)\frac{\tau_2}{p_2} \\ (\mu_{21}-\eta_2 w_1)\frac{\tau_1}{p_1} + (\mu_{22}-\eta_2 w_2)\frac{\tau_2}{p_2} \end{bmatrix} \tag{24}$$

Equation (24) will be used for the optimization exercise in order to find the values for the restrictions describe in section 4.2.

Note that as we have assumed $\varepsilon_{ii} = \infty$ we have:

$$q_L + \Delta q_L = q_L\left(\frac{p_L + \Delta p_L}{p_L}\right)^{(\mu_{LL}-\eta_L w_L)}\left(\frac{p_O + \Delta p_O}{p_O}\right)^{(\mu_{LO}-\eta_L w_O)}$$

$$q_O + \Delta q_O = q_O\left(\frac{p_L + \Delta p_L}{p_L}\right)^{(\mu_{OL}-\eta_O w_L)}\left(\frac{p_O + \Delta p_O}{p_O}\right)^{(\mu_{OO}-\eta_O w_O)}$$

5. Data used and optimisation

- The data used in this paper was collected by the company **CPS, Estudios de Mercado y Opinión S.L.** during January 2012 from 11 different retailers in 6 representative Spanish provinces for three types of household appliances: dishwashers, refrigerators and washing machines. (see Lucas and Galarraga (2015). These provinces were: Galicia, the Basque Country, Valencia, Seville, Madrid and Barcelona.

- The values for the Hicksian elasticities are calculated from Slutsky equation,

$$\mu_{ii} = \mu_{ii}^{H} - w_i \eta_i$$

5. Data used and optimisation

	Washing machines					
Parameter	Case I	Case II	Case III	Case IV	Case V	Case VI
Quantities Labelled (L)	189,240	189,240	189,240	189,240	189,240	189,240
Quantities Other (O)	1,623,401	1,623,401	1,623,401	1,623,401	1,623,401	1,623,401
Prices L	497.25	497.25	497.25	497.25	497.25	497.25
Prices O	477.44	477.44	477.44	477.44	477.44	477.44
Exp. Share L	0.000181	0.000181	0.000181	0.000181	0.000181	0.000181
Exp. Share O	0.001492	0.001492	0.001492	0.001492	0.001492	0.001492
Own P elast of Demand L (Marshallian)	-1.22	-3.28	-5.34	-7.40	-9.46	-11.52
Cross P elast of Demand L-O (Marshallian)	0.82	2.88	4.94	7.00	9.06	11.11
Cross P elast of Demand O-L (Marshallian)	0.1	0.35	0.6	0.85	1.1	1.35
Own P elast of Demand O (Marshallian)	-0.5	-0.75	-1	-1.25	-1.5	-1.75
Income elast. L	0.4	0.4	0.4	0.4	0.4	0.4
Income elast O	0.4	0.4	0.4	0.4	0.4	0.4

5. Data used and optimisation: HICKSIAN elasticities

	Dishwashers				Refrigerators		
Parameter	Case I	Case II	Case III	Case IV	Case I	Case II	Case III
Own P elast of Demand L	-2.04	-6.15	-10.26	-14.37	-1.71	-5.00	-8.29
Cross P elast of Demand L-O	1.65	5.77	9.89	14.01	1.32	4.62	7.92
Cross P elast of Demand O-L	0.10	0.35	0.60	0.85	0.10	0.35	0.60
Own P elast of Demand O	-0.50	-0.75	-1.00	-1.25	-0.50	-0.75	-1.00

Washing machines					
Case I	Case II	Case III	Case IV	Case V	Case VI
-1.22	-3.29	-5.35	-7.41	-9.47	-11.53
0.82	2.88	4.94	7.00	9.06	11.12
0.10	0.35	0.60	0.85	1.10	1.35
-0.50	-0.75	-1.00	-1.25	-1.50	-1.75

5. Data used and optimisation

$$\mathbf{S} = \begin{bmatrix} \mu^{H}{}_{1,1}\frac{q_1}{P_1} & \mu^{H}{}_{1,2}\frac{q_1}{P_2} & \dots & \mu^{H}{}_{1,39}\frac{q_1}{P_{39}} \\ \mu^{H}{}_{2,1}\frac{q_2}{P_1} & \mu^{H}{}_{2,2}\frac{q_2}{P_2} & \dots & \mu^{H}{}_{2,39}\frac{q_2}{P_{39}} \\ \mu^{H}{}_{3,1}\frac{q_3}{P_1} & \mu^{H}{}_{3,2}\frac{q_3}{P_2} & \dots & \mu^{H}{}_{3,39}\frac{q_3}{P_{39}} \\ \dots & \dots & \dots & \dots \\ \mu^{H}{}_{39,1}\frac{q_{39}}{P_1} & \mu^{H}{}_{39,2}\frac{q_{39}}{P_2} & \dots & \mu^{H}{}_{39,39}\frac{q_{39}}{P_{39}} \end{bmatrix} \quad (27)$$

Where every elasticity are Hickisians. The DWL will be:

$$DWL = -\frac{1}{2}\mathbf{x}'\mathbf{S}\mathbf{x} \quad (28)$$

Being,

$\mathbf{x}' = [x_1 \quad x_2 \quad \dots \quad]$ and $x_i = \Delta P_i = \tau_i$

To minimise DWL we define the following:

$$\min_{\mathbf{x}} DWL(\mathbf{x}) \quad (29)$$

5. Data used and optimisation

We minimise DWL s.t

- Restricting emissions of CO_2.
- Generating no deficit for the public budget.
- Increasing (decreasing) the number of labelled (non-labelled) appliances.

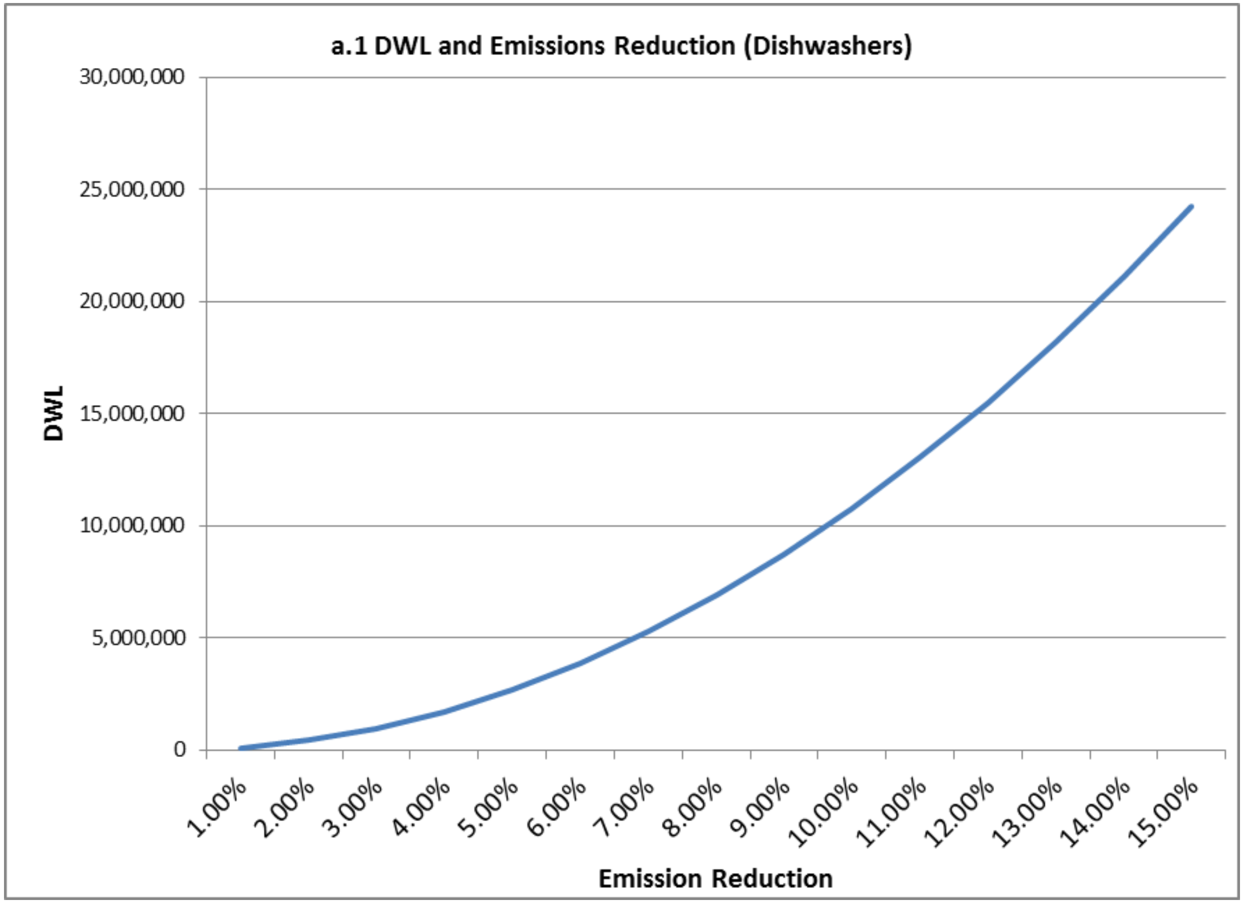
- **CAVEAT:**
  - As we only have equations for two unknowns, when two restrictions are used, we are not really minimising the DWL but calculating the resulting DWL.
  - This is a caveat of the data used for this analysis but not of the methodology as when more information will become available the minimisation exercise will be easily done.

6. Results: Energy savings (only Dishwashers)

Results for the case of Dishwashers with energy savings (a.1)

Dishwashers Case I				
Emission reduction	**1%**	**5%**	**10%**	**15%**
Subsidy (L)	-10.98	-54.89	-109.78	-164.68
Tax (O)	12.07	60.34	120.68	181.02
DWL	107,659.99	2,691,499.74	10,765,998.97	24,223,497.69
qL0	99,134	99,134	99,134	99,134
qO0	1,700,030	1,700,030	1,700,030	1,700,030
qL1	98,788.14	97,404.71	95,675.42	93,946.14
qO1	1,682,442.78	1,612,093.94	1,524,157.87	1,436,221.80
pL0	501.46	501.46	501.46	501.46
pO0	482.03	482.03	482.03	482.03
pL1	512.44	556.35	611.24	666.13
pO1	494.10	542.37	602.71	663.05
Unit consumption L	260.91	260.91	260.91	260.91
Unit consumption O	286.54	286.54	286.54	286.54
Consumption I (MWh/year)	512,992	512,992	512,992	512,992
Consumption F (MWh/year)	507,862	487,343	461,695	436,046
Δ Consumption (MWh/year)	-5,130	-25,648	-51,297	-76,945
Δ Consumption (%)	-1.00%	-5.00%	-10.00%	-15.00%
Δ Domestic Appliances	-17,933	-89,665	-179,331	-268,996
Net tax+subsidy	-21,388,220	-102,620,322	-194,438,688	-275,455,098

6. Results: Energy savings (only Dishwashers)



6. Results: Energy savings (only Dishwashers)

Results for the case of Dishwashers with energy savings (a.2)

Dishwashers Case I				
Emission reduction	1%	5%	10%	15%
Subsidy (L)	0	0	0	0
Tax (O)	12.28	61.41	122.83	184.24
DWL	132,846.03	3,321,150.7	13,284,602.81	29,890,356.32
qL0	99,134	99,134	99,134	99,134
qO0	1,700,030	1,700,030	1,700,030	1,700,030
qL1	103,296.41	119,946.07	140,758.15	161,570.22
qO1	1,678,343.59	1,591,597.93	1,483,165.86	1,374,733.78
pL0	501.46	501.46	501.46	501.46
pO0	482.03	482.03	482.03	482.03
pL1	501.46	501.46	501.46	501.46
pO1	494.31	543.44	604.85	666.27
Unit consumption L	260.91	260.91	260.91	260.91
Unit consumption O	286.54	286.54	286.54	286.54
Consumption I (MWh/year)	512,992	512,992	512,992	512,992
Consumption F (MWh/year)	507,864	487,352	461,712	436,072
Δ Consumption (MWh/year)	-5,128	-25,640	-51,280	-76,920
Δ Consumption (%)	-1.00%	-5.00%	-10.00%	-14.99%
Δ Domestic Appliances	-17,524	-87,620	-175,240	-262,860
Net tax+subsidy	-20,614,281	-97,744,132	-182,170,077	-253,277,837

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6. Results: Budget neutrality (only Dishwashers)

Results for the case of Dishwasher under budget neutrality

Dishwashers Case I								
Subsidy	20	45	75	85	90	95	100	105
Tax	1.27	3.17	5.92	6.96	7.50	8.06	8.63	9.22
DWL	90,865.77	466,348.3	1,317,869	1,702,788	1,914,745	2,139,871	2,378,297	2,630,160
qL0	99,134	99,134	99,134	99,134	99,134	99,134	99,134	99,134
qO0	1,700,030	1,700,030	1,700,030	1,700,030	1,700,030	1,700,030	1,700,030	1,700,030
qL1	107,646	118,390.5	131,443.7	135,835	138,038.5	140,247.2	142,461.2	144,680.6
qO1	1,691,004	1,679,178	1,664,154	1,658,936	1,656,287	1,653,610	1,650,905	1,648,173
pL0	501.46	501.46	501.46	501.46	501.46	501.46	501.46	501.46
pO0	482.03	482.03	482.03	482.03	482.03	482.03	482.03	482.03
pL1	481.46	456.46	426.46	416.46	411.46	406.46	401.46	396.46
pO1	483.30	485.20	487.95	488.99	489.53	490.09	490.663	491.25
Unit consumption L	260.91	260.91	260.91	260.91	260.91	260.91	260.91	260.91
Unit consumption O	286.54	286.54	286.54	286.54	286.54	286.54	286.54	286.54
Consumption I (MWh/year)	512,992	512,992	512,992	512,992	512,992	512,992	512,992	512,992
Consumption F (MWh/year)	512,626	512,041	511,142	510,792	510,608	510,417	510,220	510,016
Δ Consumption (MWh/year)	-365	-951	-1,850	-2,199	-2,384	-2,574	-2,772	-2,976
Δ Domestic appliances	-514	-1,595	-3,566	-4,393	-4,839	-5,307	-5,798	-6,311
Net tax+subsidy	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6. Results: Total number constant (only Dishwashers)

Results for the case of Dishwashers with total number constant

Dishwashers Case I								
Subsidy	20	45	75	85	90	95	100	105
Tax	0.91	2.05	3.42	3.88	4.11	4.34	4.56	4.79
DWL	87730.81	444137.22	1233714.5	1584637.7	1776548.89	1979426.4	2193270.2	2418080.4
qL0	99134	99134	99134	99134	99134	99134	99134	99134
qO0	1700030	1700030	1700030	1700030	1700030	1700030	1700030	1700030
qL1	107524	118011.55	130596.59	134791.6	136889.106	138986.61	141084.12	143181.62
qO1	1691640	1681152.4	1668567.4	1664372.4	1662274.89	1660177.4	1658079.9	1655982.4
pL0	501.46	501.46	501.46	501.46	501.46	501.46	501.46	501.46
pO0	482.03	482.03	482.03	482.03	482.03	482.03	482.03	482.03
pL1	481.46	456.46	426.46	416.46	411.46	406.46	401.46	396.46
pO1	482.94	484.08	485.45	485.91093	486.139221	486.36751	486.5958	486.82409
Unit consumption L	260.91	260.91	260.91	260.91	260.91	260.91	260.91	260.91
Unit consumption O	286.54	286.54	286.54	286.54	286.54	286.54	286.54	286.54
Consumption I (MWh/year)	512,992	512,992	512,992	512,992	512,992	512,992	512,992	512,992
Consumption F (MWh/year)	512,777	512,508	512,185	512,078	512,024	511,970	511,916	511,863
Δ Consumption (MWh/year)	-215	484	-806	-914	-968	-1,021	1,075	-1,129
Δ Domestic appliances	0	0	0	0	0	0	0	0
Net tax+subsidy	605,742	1,856,406	4,080,984	4,997,972	5,489,365	6,002,690	6,537,949	7,095,140

7. Concluding remarks

- We propose the use of Bonus-Malus schemes to promote the purchase of more efficient appliances because:
  - It can be efficient
  - Generated no deficit
  - Can be designed to reduce energy consumption
  - Consumer can choose whether to receive a subsidy or pay a tax.
- A method is presented to design such a policy. Minimise DWL subject to ANY condition.
- The case study for two goods and this limits the applicability, but can be applied to n goods (currently working with 41 goods!).

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Thank you!