The price impacts of an environmental tax on production of goods in the Spanish economy

Gemechu E.D.[1*], Butnar I.[1], Llop M.[2] , Amores Barrero M. J.[1], Castells F.[1]

[1]Departament d'Enginyeria Química, Universitat Rovira i Virgili, Av. Països Catalans 26, 43007 Tarragona, Spain
[2]Centre de Recerca en Economia Industrial i Pública (CREIP), Departament d'Economia, Universitat Rovira i Virgili, Av. Universitat n° 1, 43204 Reus, Spain
[*]eskinderdemisse.gemechu@urv.cat
Tel: (34) 977 55 8553
Fax:(34) 977 55 9621

There is an ever increasing concern of climate change around the globe as different researchers reveal the unequivocalness of climate change and the urgent need of response to effective mitigation options. CO_2 emissions induced by human activities are the major causes of climate change; hence, strong environmental policy that limits the growing dependence on fossil fuel is indispensable. Tradable permit and environmental tax are among the main tools used in CO_2 reduction strategies. Such economic tools provide incentives to polluting industries for any positive measure they take to reduce their emissions through market signals. The aim of this work is to define an environmental tax on products and services based on their life cycle CO_2 emissions. We examined the relevance of environmentally extended input-output analysis as methodological tool to identify emission intensities of products and services on which the tax is based. The short-term price effects are analyzed using input-output price model. The effect of tax introduction on consumption prices and its influence on consumers' welfare are determined. The results, based on the Spanish economic and environmental data for the year 2007, show that sectors such as Production and distribution of electricity; Manufacture and distribution of gaseous fuels; Collection, purification and distribution of water; Manufacture of other non-metallic mineral products; Manufacture of cement, lime and plaster; Manufacture of glass and glass products; Manufacture of ceramic products are among the most polluting sectors that exhibit relatively higher emission intensities and environmental taxes. The tax on CO_2 emissions increases the production price of all sectors without any exception. The consumption price index is estimated to be increased by 1.74%. The increased consumer's price index has a negative effect on the private welfare which is subjected to a drop of 1,148 million Euros. The results in general show the most important sectors which are relatively sensitive to price changes due to environmental taxes imposition and how such a policy enhances the environment as it ensures reductions in productions and consumptions.

1. Introduction

Concern about climate change has increased as different researches reveal that global warming is unquestionable at this point in time (IPPC 2007; Stern et al. 2006). Human activities are believed to be the major causes of a massive greenhouse effect and no effort in GHG emissions reduction will end up in rising the global average temperature and results in unpredictable consequences. Hence, there is an urgent need for action on climate change in order to outweigh its potential cost when no changes in policies will take place (Stern et al. 2006). This has opened up a door for different environmental measures to be considered as a policy agenda. Environmental tax and tradable permits are among the economic market instruments which have been considered and implemented in order to control anthropogenic GHG emissions by limiting the growing dependence on fossil fuel. Such economic tools provide incentives to polluting industries and consumers for any positive measure taken to reduce emissions through market signals.

The significance of Market Based Instruments (MBIs) in general and environmental tax in particular as a policy for climate change mitigation was one of the issues addressed in the Earth Summit held in Rio de Janeiro two decades ago. MBIs are highlighted both in the Rio Declaration (UN, 1992a) and Agenda 21 (UN, 1992b) as a potential policy tool for national authorities to promote the internalization of environmental costs through the principle that polluters should bear the full cost of pollution. Such policy tools are believed to trigger and disseminate technological innovation and alter both the unsustainable production and consumption patterns (Panayotou, 1994). A decade later, the Sixth community action, the European Union (EU) program that defines the priorities and objectives of European environment policy, recommends the use of economic instruments to promote sustainable production and consumption patterns (European Commission, 2002). Environmental taxes are well thought-out policies to be environmentally effective and economically efficient among economic instruments. So far, different studies have been conducted to assess the potential use of environmental taxes in GHG managements (Smith, 1992; OECD, 1993, 1996; Bovenberg and Cnossen, 1995; Fullerton, 2001; Bovenberg and Goulder, 2002; Stavins, 2003; Newell and Stavins, 2003). The principle behind an environmental tax is that a defined levy is introduced on environmentally polluting products or services based on the potential cost of climate change effects caused by their production and consumption. By internalizing the negative externalities (e.g. CO_2 emissions) and reflecting them in the price, the introduction of an environmental tax would raise the prices of polluting products and services, and decrease the relative prices of environmentally friendly products. This would give consumers more information on the environmental profile of the products and services they purchase and could lead to a more sustainable consumption and production through promoting environmentally friendly products. However, distributional effects and global competitiveness are among the main shortcomings of environmental tax. The manner in which environmental tax treats different income groups in an economy is an important element that limits its applicability. Environmental tax is often considered as a regressive tax as it imposes a higher burden on low-income households than high-income households. In addition, imposing an environmental tax increases the cost of highly polluting energy sources and consequently increases the cost of production. Hence, domestic industries may lose their global competitiveness when they are competing with foreign producers from countries where similar environmental policies are not applied. Therefore, policy reforms are

required in order to counter balance such negative implications and to make these instruments worthwhile (Fullerton et. al., 2008; Parry et al., 2003; Poterba, 1993).

One of the biggest challenges with environmental tax implementation is the identification of a proper tax rate because setting the desired level of tax that could influence both consumers and producers is a very complex issue. A properly designed tax can play an important role in moving the world closer to sustainability by reducing human related emissions due to production and consumption. The cost effectiveness and the dynamic incentives for technology innovation are the two most notable advantages over the command-and-control (Jaffe and Stavins, 1995). The aim of this work is to define an environmental tax on products and services based on their life cycle CO_2 emissions. We examined the relevance of environmentally extended input-output analysis as methodological tool to identify emission intensities of products and services on which the tax is based. Besides the environmental tax calculation, this study will try to answer the questions on how different sectors respond to the environmental tax, what are the economic impacts of the tax, and how does it affect the individual consumers' welfare. These are mainly analysed by implementing the input-output price model.

This paper is organized as follows: the second section explains about the methodological issue, both environmental tax calculation and impact assessment. The third section is dedicated to results and discussions. Finally, conclusions are drawn and the policy implications of the results are presented.

2. Methodology

The environmental tax is defined based on the CO_2 emissions of products and services produced in the Spanish national economy. Environmentally extended input-output (EIO) analysis is the methodology chosen for CO_2 emissions intensities estimation. EIO is a top-down approach used to account for resource consumption and emissions release based on economic input-output tables (Miller and Blair, 2009; Matthews et al., 2008; Suh and Huppes, 2005). The approach uses generic data at national levels to evaluate the emission intensities of each industry in an economy (vector *m* in Eq-1) to produce a euro output necessary to satisfy a given final demand. The EIO model is derived from the Leontief input-output table, which was initially developed by Wassily Leontief in the 1930s, for which he received a Nobel Prize in Economics. The model is symmetric in nature as it is based on a one-to-one industry and product relationship, i.e. each industry is assumed to produce only one product and each product is produced by only one industry. It is represented in matrix notation as follows:

$$m = e^{'}(I - A)^{-1} \qquad \text{Eq-1}$$

I is *NxN* identity matrix, where *n* stands for number of industries in the economy. *A* is *NxN* matrix of technical coefficients, whose element a_{ij} measures the flow from industry *i* required to produce 1€ output of industry *j*. *e* is a raw vector of industrial emissions in which each element e_i represents the amount of CO_2 emissions released to produce 1€ output of industry *i*.

EIO model has important features that make it one of the potential methodological approaches for products and services carbon intensity estimation. One of these features is its completeness. EIO model links all industries in a given economy and hence,

facilitates an assessment of the interdependence of industries. Another feature is its ability to assess both direct and indirect emissions explicitly. These features together allow covering all emissions associated with the final demand of a given product.

The environmental tax on production is then estimated by multiplying the emissions intensity of production sectors by carbon price φ, expressed in €/ton of CO_2. Here, the CO_2 tradable permit price by EU-Emissions-Trading System (EU ETS) is considered as an equivalent environmental tax.

$$t_e = \varphi\, e'\, (I - A)^{-1} \qquad \text{Eq-2}$$

Once the environmental tax for each product and service is defined, then the potential impacts on the economy is analysed using the Leontief price model. The price model is formulated on the basis of two basic assumptions: fixed proportion, under the assumption of constant returns to scale and no consumer's utility function. The former assumption is the same assumption made in EIO model in which each industry produces a unique product and there is a fixed relationship between each sector output and all its inputs. This assumption usually ignores the economies of scale in production. The later totally ignores the price and final demand relationship. So far different studies have been conducted that used the Leontief price model for different policy analysis such as to assess the effect of indirect taxes (Manresa et al, 1988; De Miguel, 2003), to study the effect of import price alternation and sectoral inputs on the cost of production (McKean and Taylor, 1991; Llop and Manresa, 2004), to analyse the economic impacts of alternative water policies on the Spanish production system (Llop and Pié, 2008), to site but a few.

Assuming that the sectoral prices are equal to the average cost of production, the price p_j of each sector j can be expressed as the total cost of intermediate inputs and total value-added expenditure as follows (Llop, 2005):

$$P_j = (1+\tau_j)\left[\sum_{i=1}^{73} p_i a_{ij} + (1+s_j) w l_j + r k_j + (1+t^m_j) p^m_j m_j\right] \qquad \text{Eq-3}$$

where τ_j is the ad-valorem tax on the production in net terms, a_{ij} is the input-output technical coefficient, s_j is the tax rate of social Security paid by sector j, w is price of labour (wage), l_j is the labour coefficient, r is the price of capital, k_j is the coefficient of capital, t^m_j is the ad-valorem rate of the imports in sector j, p^m_j is the price of import and m_j is import coefficient. The price after the introduction of the environmental tax t_{ej} is estimated as:

$$P_j = (1+\tau_j)(1+t_{ej})\left[\sum_{i=1}^{73} p_i a_{ij} + (1+s_j) w l_j + r k_j + (1+t^m_j) p^m_j m_j\right] \qquad \text{Eq-4}$$

The above production price can be expressed in matrix form:

$$p = (I - A^*)^{-1} b \qquad \text{Eq-5}$$

Where A^* is the new technical coefficient matrix that incorporates both the ad-valorem tax and environmental tax and b is the vector of value added which includes the capital, labour and import variables.

The impact of environmental tax in the economy which resulted in changes in production price can also be analysed from consumption price index change and change in individual welfare. Consumption prices are indexes that examine the weighted average prices of basket of goods consumed by households and they are calculated by using a normalized basket of goods, which define the weights of the final prices:

$$p_c = \sum_{j=1}^{73} p_j \alpha_j , \qquad \text{Eq-6}$$

where p_j is the production price of goods from sector j and α_j stands for the share of final goods from sector j as a ratio of the total goods consumed in the economy.

The impact of the tax on the private real income, could be refereed as change in consumer's welfare, can be approximated using the following expression:

$$\Delta W = W - W' = \sum_{j=1}^{73} p_{cj} C_j - \sum_{j=1}^{73} p'_{cj} C_j \qquad \text{Eq-7}$$

where p_j and p_j' are the consumption prices before and after the introduction of environmental tax respectively, C_j is the consumption of goods from sector j. Any positive value in the change of welfare corresponds to the situation in which there is a minimized individual consumer's benefit as a result of consumption of goods and services. A negative result represents a worse situation in which there is reduction in individual consumer's welfare.

Data sources

For the empirical application, the following data sources were used:

- The data on CO_2 emissions were obtained from the Satellite Atmospheric Emissions Accounts for Spain provided by the Spanish Institute of Statistics for the year 2007 (INE 2010a). The emission data were aggregated into 47 industries and total output factors were used to disaggregate them into 73 industries in order to be consistent with the EIO model.
- The economic data on sectoral transactions come from the Supply and Use tables published by the Spanish Institute of Statistics for the same year 2007 (INE 2010b). The Supply and Use tables are disaggregated into 73 industries and 118 products and they were used to derive the industry-by-industry and commodity-by-industry total requirement matrices necessary in Eq-1.
- The data on the ad-valorem tax t on industries were calculated from the Use table by dividing the Taxes less subsidies on products by the total sectorial uses in basic prices.

3. Results and discussion

EIO allows for assessing the environmental taxes based on CO_2 emission intensities for all the products and services within the Spanish economy. Table 1 summarizes the top 25 industries that would be subjected to the highest environmental tax when it is levied based on their emission intensities per € output. As can be seen, sectors which are highly affected from the tax are those sectors known for their high energy intensive processes, such as cement production, glass production, ceramic production and mining of coal.

Table 1. CO_2 tax for the top 25 polluting industries

Input-Output sectors	Industry code	Tax rate (%)
Production and distribution of electricity	9	6.08
Manufacture of gas; distribution of gaseous fuels through mains; steam and hot water supply	10	5.36
Collection, purification and distribution of water	11	4.33
Manufacture of other non-metallic mineral products	28	4.23
Manufacture of cement, lime and plaster	25	3.98
Manufacture of glass and glass products	26	3.86
Manufacture of ceramic products	27	3.71
Water transport	48	3.49
Manufacture of coke, refined petroleum products and nuclear fuel	8	3.42
Mining of coal and lignite; extraction of peat	4	2.77
Air transport	49	2.66
Extraction of crude petroleum and natural gas; mining of uranium and thorium ores	5	2.42
Other land transport; transport via pipelines	47	1.65
Manufacture of chemicals and chemical products	23	1.52
Manufacture of basic metals	29	1.44
Manufacture of pulp, paper and paper products	21	1.32
Other mining and quarrying	7	1.27
Manufacture of fabricated metal products, except machinery and equipment	30	1.27
Recycling	39	1.10
Manufacture of textiles	17	1.10
Manufacture of beverages	15	1.08
Manufacture of dairy products	13	1.04
Agriculture, livestock and hunting	1	1.02
Mining of metal ores	6	1.01
Manufacture of other food products	14	1.01

The highest environmental tax is levied on Production and distribution of electricity (sector 9), which exhibits 6.08% tax rate. This is due to its poor environmental profile, as its production is mainly relayed on inputs from highly polluting sectors such as Manufacture of gas; distribution of gaseous fuels through mains; steam and hot water supply (sector 10), Manufacture of coke, refined petroleum products and nuclear fuel (sector 8) and Mining of coal and lignite; extraction of peat (sector 4). The share of renewable energy source is significantly low in the national energy mix.

Manufacture of gas; distribution of gaseous fuels through mains; steam and hot water supply (sector 10) and Collection, purification and distribution of water (sector 11) are also subjected to high environmental tax, 5.36% and 4.33% respectively. The high emission intensity and then environmental tax of sector 11 resulted from high inputs requirements from energy and emissions intensive sectors such as Manufacture of machinery and equipment, Manufacture of chemicals and chemical products, Manufacture of coke, refined petroleum products and nuclear fuel and Production and distribution of electricity.

Table 2. Changes in production prices (%) when environmental taxes based on CO_2 emissions intensity are applied on selected industrial sectors

Input-Output sectors	**Sectors code**	**sector 9**	**sector 10**	**sector 11**	**sector 28**	**sector 25**
Agriculture, livestock and hunting	1	0.151	0.027	0.036	0.010	0.005
Forestry, logging and related service activities	2	0.018	0.003	0.003	0.002	0.001
Fishing, operation of fish hatcheries and fish farms	3	0.067	0.027	0.010	0.005	0.002
Mining of coal and lignite; extraction of peat	4	0.365	0.044	0.005	0.010	0.009
Extraction of crude petroleum and natural gas; mining of uranium and thorium ores	5	0.003	0.004	0.000	0.000	0.000
Mining of metal ores	6	0.014	0.003	0.001	0.002	0.001
Other mining and quarrying	7	**0.494**	0.082	0.027	0.033	0.018
Manufacture of coke, refined petroleum products and nuclear fuel	8	0.037	0.010	0.004	0.002	0.001
Production and distribution of electricity	9	**7.646**	**0.814**	0.016	0.017	0.008
Manufacture of gas; distribution of gaseous fuels through mains; steam and hot water supply	10	0.117	**5.381**	0.002	0.005	0.002
Collection, purification and distribution of water	11	0.221	0.043	**4.343**	0.016	0.008
Manufacture of meat products	12	0.208	0.045	0.025	0.011	0.004
Manufacture of dairy products	13	0.234	0.070	0.021	0.012	0.004
Manufacture of other food products	14	0.180	0.057	0.020	0.011	0.004
Manufacture of beverages	15	0.203	0.052	0.036	0.021	0.006
Manufacture of tobacco products	16	0.077	0.015	0.006	0.005	0.002
Manufacture of textiles	17	0.157	0.054	0.012	0.008	0.003
Manufacture of wearing apparel; dressing and dyeing of fur	18	0.079	0.024	0.007	0.004	0.002
Manufacture of leather and leather products	19	0.151	0.029	0.009	0.006	0.002
Manufacture of wood and products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20	0.217	0.044	0.010	0.011	0.003
Manufacture of pulp, paper and paper products	21	0.362	0.156	0.010	0.011	0.004
Publishing, printing and reproduction of recorded media	22	0.254	0.062	0.010	0.010	0.004
Manufacture of chemicals and chemical products	23	0.162	0.071	0.011	0.009	0.003
Manufacture of rubber and plastic products	24	0.279	0.068	0.011	0.009	0.003
Manufacture of cement, lime and plaster	25	**0.576**	0.099	0.012	0.182	**4.224**
Manufacture of glass and glass products	26	0.249	0.158	0.012	0.088	0.019
Manufacture of ceramic products	27	0.259	**0.294**	0.014	0.096	0.021
Manufacture of other non-metallic mineral products	28	**0.451**	0.091	0.015	**4.375**	**0.653**
Manufacture of basic metals	29	0.237	0.078	0.007	0.021	0.005
Manufacture of fabricated metal products, except machinery and equipment	30	0.236	0.056	0.009	0.017	0.004
Manufacture of machinery and equipment n.e.c.	31	0.130	0.028	0.005	0.013	0.003
Manufacture of office machinery and computers	32	0.029	0.006	0.002	0.002	0.001
Manufacture of electrical machinery and apparatus n.e.c.	33	0.192	0.040	0.005	0.010	0.003
Manufacture of electronic equipment and apparatus	34	0.048	0.010	0.002	0.004	0.001
Manufacture of medical, precision and optical instruments	35	0.066	0.013	0.003	0.009	0.002
Manufacture of motor vehicles, trailers and semi-trailers	36	0.125	0.030	0.004	0.006	0.002
Manufacture of other transport equipment	37	0.139	0.032	0.006	0.011	0.003

Manufacture of furniture; manufacturing n.e.c.	38	0.120	0.028	0.007	0.012	0.003
Recycling	39	0.261	0.070	0.012	0.021	0.006
Construction	40	0.143	0.035	0.009	**0.373**	0.100
Sale and retail of motor vehicles; retail sale of automotive fuel	41	0.203	0.034	0.011	0.013	0.005
Wholesale trade and commission trade services	42	0.222	0.046	0.017	0.013	0.006
Retail trade services; repair of personal and household goods	43	0.303	0.054	0.017	0.018	0.006
Hotels, camping sites and other provision of short-stay accommodation	44	0.125	0.027	0.017	0.024	0.008
Restaurants	45	0.110	0.026	0.015	0.013	0.005
Transport via railways	46	**0.668**	0.089	0.025	0.016	0.005
Other land transport; transport via pipelines	47	0.089	0.031	0.035	0.010	0.003
Water transport	48	0.231	0.045	0.019	0.012	0.004
Air transport	49	0.075	0.013	0.005	0.010	0.003
Supporting and auxiliary transport activities	50	0.188	0.032	0.013	0.028	0.008
Activities of travel agencies	51	0.096	0.019	0.009	0.015	0.006
Post and telecommunications	52	0.286	0.044	0.010	0.036	0.023
Financial intermediation, except insurance and pension funding	53	0.057	0.010	0.002	0.007	0.002
Insurance and pension funding, except compulsory social security	54	0.072	0.013	0.003	0.010	0.003
Activities auxiliary to financial intermediation	55	0.133	0.020	0.005	0.013	0.004
Real estate activities	56	0.061	0.011	0.004	0.040	0.011
Renting of machinery, personal and household goods	57	0.157	0.026	0.013	0.015	0.008
Computer and related activities	58	0.094	0.023	0.007	0.015	0.005
Research and development	59	0.124	0.020	0.007	0.011	0.004
Other business activities	60	0.127	0.024	0.007	0.011	0.005
Public Administration and defence; compulsory social security	61	0.203	0.039	0.012	0.010	0.004
Market education	62	0.089	0.021	0.009	0.014	0.004
Non-market education	63	0.091	0.019	0.008	0.005	0.001
Market health and social work	64	0.078	0.020	0.008	0.011	0.003
Non-market Health and social work. General government	65	0.111	0.029	0.013	0.008	0.003
Market sewage and refuse disposal, sanitation and similar activities	66	0.212	0.051	**0.114**	0.010	0.003
Non-market sewage and refuse disposal, sanitation and similar activities. General government	67	0.274	0.060	**0.274**	0.054	0.015
Market activities of membership organization n.e.c.	68	0.119	0.034	0.017	0.008	0.003
Non-market activities of membership organization n.e.c. NPISHs	69	0.153	0.036	0.027	0.012	0.005
Market recreational, cultural and sporting activities	70	0.070	0.015	0.006	0.011	0.003
Recreational, cultural and sporting activities. NPISHs	71	0.227	0.046	0.027	0.028	0.010
Other service activities	72	0.237	0.045	0.048	0.034	0.008
Private households with employed persons	73	0.000	0.000	0.000	0.000	0.000

As summarized in Table 2 the Leontief price model allows seeing how sectors in an economy reacts to changes in policy. Introduction of environmental tax on the Production and distribution of electricity increase the production price of the sector by 7.65%. Sectors such as Transport via railways, Manufacture of cement, lime and plaster; Other mining and quarrying; Manufacture of other non-metallic mineral products; Mining of coal and lignite; extraction of peat; and Manufacture of pulp, paper and paper products are among the most sensitive sectors that are subjected to high production price change when environmental tax is introduced on the production and distribution of electricity. Those sectors are well known for their high electricity requirements in order to produce their outputs.

Environmental tax on Manufacture of gas; distribution of gaseous fuels through mains; steam and hot water supply (sector 10) increases its production price by 5.4%. Though the highest impact is observed in the sector itself, Production and distribution of electricity and Manufacture of ceramic products are among the sectors that are relatively affected, showing a price change of 0.8% and 0.3% respectively. The effect on the other sector is not significant.

The tax on the Collection, purification and distribution of water almost has no effect on the other sectors but on Market sewage and refuse disposal, sanitation and similar activities and Non-market sewage and refuse disposal, sanitation and similar activities. They are among the major consumer of intermediate water from the sectors in which together are responsible for the consumption of around 10% of the total water supple of the sector.

Environmental tax on Manufacture of other non-metallic mineral products increase its production price by 4.4% and it also affect the Construction sector which faces a price change of 0.4%.

When the environmental taxes are applied simultaneously in all sectors, it stimulates a general increase in production prices in all sectors without any exception; consequently the consumption price index and individual household welfare are impacted. The consumer price index was approximated from the changes in the sectoral prices and sectoral consumption. The spectral consumptions are generated from the supply and use table for the activity year 2007. The tax on CO_2 emissions increases the consumption price index by 1.74%. As a result of consumption price index increase, the individual welfare is negatively affected, which shows a reduction of 1,148 million euros.

Conclusion

The results in general show how the implementation of environmental tax affects the production prices of different sectors in the national economy. These kinds of analysis can be used by policy makers as they help them understand how environmental policy action on a given sector could affect others. From the result we can conclude that environmental tax could be an alternative policy in order to reduce the climate change impacts due to unsustainable productions and consumptions. The taxes based on CO_2 emission intensities for selected sectors resulted in increasing the production price of all sectors consequently increase the consumer price index and decrease consumers' welfare. This shows how consumer price index and welfare are influenced by changes in production cost. Increase in production prices also could also reduce both

intermediate and final consumption, making environmental tax a worthwhile policy for climate change mitigation.

Finally, it is important to bear in mind the assumptions in which both input-output and the price modes are based on when interpreting the results. As have already been explained input-output model fix the technology, therefore, all the effects associated with the environmental tax are short-term effects. Any technological improvement towards environmental enhancement could not be reflected in the model. Likewise, the price model formulation totally ignores the interdependence of price and final demand. Therefore, such limitations of the models should be taken into account.

Acknowledgement

This work has been financially supported by the Spanish Ministerio de Educación y Cultura (grant ECO2010-17728) and the Generalitat de Catalunya (grants SGR2009-322 and 2009SGR-230).

References

Bovenberg, A.L., and Conssen, S., 1995. Public Economics and the Environment in an Imperfect World. Kluwer Academic Publishers.

Bovenberg, A.L., and Goulder, L.H., 2002. Environmental taxation and regulation. Handbook of Public Economics, in: A.J. Auerbach and M. Feldstein (ed.), Handbook of Public Economics, edition 1, vol 3, 471-1545 Elsevier.

De Miguel, J., 2003. Matrices de contabilidad social y modelización de equilibrio general: una aplicación para la economía extremeña. Ph.D. Thesis. Departamento de Economía Aplicada y Organización de Empresas, Universidad de Extremadura.

European Commissions (EU), 2002. Decision No 1600/2002/EC Of the European Parliament and of the Council of 22 July 2002 laying down the Sixth Community Environment Action Programme. Official Journal of the European Communities. L 242.

Fullerton, D., 2001. A Framework to Compare Environmental Policies. Southern Economic Journal, 68, 224-238.

Fullerton, D., Leicester, A., Smith, S., 2008. "Environmental Taxes" Dimensions of Tax Design. Ed. Institute for Fiscal Studies (IFS). Oxford University Press, Available at: http://works.bepress.com/don_fullerton/37

Instituto Nacional de Estadística (INE), 2010a. Atmospheric emissions satellite accounts. 1990 and 1995-2003 series. Madrid http://www.ine.es/

Instituto Nacional de Estadística (INE), 2010b. Spanish National Accounts, Base 2000. Madrid http://www.ine.es/

IPCC, 2007. Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jaffe, A. B., Stavins, R.N., 1995. Dynamic Incentives of Environmental Regulation: The Effects of Alternative Policy Instruments on Technology Diffusion. Journal of Environmental Economics and Management, 29, S43-S63.

Llop, M., 2008. Economic impact of alternative water policy scenarios in the Spanish production system: An input-output analysis. Ecological economics. 68(1-2), 288 – 294

Llop, M., Manresa, A., 2004. Influencia de los precios de los factores y de las importaciones en la economía catalana (1994). Investigaciones Regionales 4, 115–129.

Llop, M., and Pié, L., 2008. Input–output analysis of alternative policies implemented on the energy activities: An application for Catalonia. Energy Policy 36, 1642–1648. Manresa, A., Polo, C., Sancho, F., 1988. Una evaluación de los efectos del IVA mediante un modelo de producción y gasto de coeficientes fijos. Revista Española de Economía 5, 45–64.

Matthews, H. S., Hendrickson, C. T., Weber, C. L., 2008. The Importance of Carbon Footprint Estimation Boundaries. Environmental Science & Technology, 42(16), 5839-5842.

McKean, J.R., Taylor, G., 1991. Sensitivity of the Pakistan economy to changes in import prices and profits, taxes or subsidies. Economic Systems Research 3, 187–203.

Miller, R. E., and Blair, P. D., 2009. Input-Output Analysis: Foundations and Extensions. Cambridge University Press, New York.

Newell, R.G. and Stavins, R.N., 2003. Cost heterogeneity and the potential savings from market based policies. Journal of Regulatory Economics, vol 23, No. 1, 43-59

OECD, 1996. Implementation Strategies for environmental taxes. The Organisation for Economic Co-operation and Development (OECD), Paris

OECD, 1993. Taxation and the Environment: Complementary Policies. The Organisation for Economic Co-operation and Development (OECD), Paris

Panayotou, T., 1994. Economic Instruments for Environmental Management and Sustainable Development. Paper prepared for UNEP's Consultative Expert Group Meeting on Use and Development of Economic Policy Instruments for Environmental Management, United Nations Environment Programme (UNEP), Environment and Economics Unit (EEU)

Parry, I., Harrington, W., Nelson, P.K., Safirova, E., Mason, D., Gillingham, K., 2003. Welfare and Distributional Effects of Road Pricing Schemes for Metropolitan Washington, DC. Resources for the Future.

Poterba, J.M., 1993. Global warming policy: A public finance perspective. Journal of Economic Perspective, 7(4), 1167 – 1182.

Smith S., 1992. The distributional consequences of taxes on energy and carbon content of fuels. European Economy special Edition, No. 1 241-268.

Stavins, R.N., 2002. Experience with Market-Based Environmental Policy Instruments. Handbook of Environmental Economics, vol 1, 355-435 Elsevier.

Stern, N., S. Peters, V. Bakhshi, A. Bowen, C. Cameron, S. Catovsky, D. Crane, S. Cruickshank, S. Dietz, N. Edmonson, S.-L. Garbett, L. Hamid, G. Hoffman, D. Ingram, B. Jones, N. Patmore, H. Radcliffe, R. Sathiyarajah, M. Stock, C. Taylor, T. Vernon, H. Wanjie, and D. Zenghelis, 2006. Stern Review: The Economics of Climate Change. HM Treasury, London.

Suh, S., and Huppes, G., 2005. Methods for Life Cycle Inventory of a product. Journal of Cleaner Production, 13(7), 687-697.

United Nations (UN), 1992a. The Rio Declaration on environment and development, the United Nations Conference On Environment and Development. Rio de Janeiro.

United Nations (UN), 1992b. Earth Summit, Agenda 21, the United Nations Conference on Environment and Development, the United Nations programme of action from Rio de Janeiro. UN, Division for Sustainable Development.