Impact of Climate Policy on the Basque Economy

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NOTA DI LAVORO 113.2005

SEPTEMBER 2005

CCMP – Climate Change Modelling and Policy

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Summary

In this paper we analyze the economic effects of CO_2 emission reductions in the Basque Country (Spain) using an applied general equilibrium (AGE) model with specific attention to environment-energy-economy interactions. Environmental policy is implemented through a system of tradable pollution permits that the government auctions. The costs of different levels of CO_2 abatement are discussed, focusing on the variations of macroeconomic, sectoral and environment-energy variables. Results show that the costs for achieving the Kyoto targets can remain limited if the appropriate combination of changes in fuel-mix and restructuring of the economy is induced.

Keywords: Applied general equilibrium, Climate change, Tradable pollution permits, Basque country

JEL Classification: D58, H21, Q20, Q48

Mikel González is grateful to the Environmental Economics and Natural Resources Group of Wageningen University for their hospitability in the period spent in Wageningen University and to Spanish Ministry of Education for financial support (FPU-ref.-2002-1001). We thank Andrea Bigano for his valuable comments on an earlier version of this paper.

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1. INTRODUCTION

Scientists have extensively studied the facts and relations between human actions, accumulation of greenhouse gases (GHGs) and climate change. One of the hottest topics on the international environmental agenda is to what extent regional emission levels should be reduced to reach global concentration targets and how local climate policy can be formulated. Projecting the local cost of GHG reduction is crucial in taking rational decisions and, hence, an extensive literature has flourished around this matter (Nordhaus, 1991; Springer, 2003; Weyant, 2004).

According to the Kyoto Protocol, Spain was allowed to increase their GHG emissions by 15% from 1990 levels by 2008-2012. In 2004, Spanish emissions had increased to 40% above 1990 levels, implying that a substantial emission reduction is required to achieve the Kyoto target. Though emission reductions do not necessarily cost money (for example, savings on energy use through 'good housekeeping'), such win-win situations are rare. Consequently, it is of increasing importance to focus on how to achieve the policy targets in a least-cost manner.

Different types of models study this subject but, so far, there are very few studies concerning empirical estimation of these effects for Spain and none for the Basque region. Labandeira et al. (2004 a,b) used an applied general equilibrium (AGE) model to study the impact of climate policy on Spain, and Manresa et al.(2004) studied the Catalonia region in an input-output framework. A few other studies investigate this issue for Spain (André et al., 2003; Gomez et al., 2004; Manresa and Sancho, 2005), but these focus primarily on the double dividend hypothesis. These studies show that the costs of immediate and medium-size reductions are not very significant in the short run and they are optimistic about the cost of attaining Kyoto objectives. All these studies agree that a double dividend is possible to achieve in Spain as the economy is highly distorted and the unemployment rate is high.

Although greenhouse gas abatement objectives are normally decided by national governments, it is important to know how these policies can affect different areas in order to develop the best adaptative actions. Moreover, the important differences in economic structure limit the extrapolation from the national to the regional level and complicate decisions about regional energy and climate policy strategies.

The Basque country is a region in Spain with a considerable level of autonomy to develop its own fiscal and energy policy. As far as climate change is concerned, the Basque country assumes national objectives but has the possibility to develop its own policy to meet targets with taxes, regulations or industrial organization plans. Energy demand in Basque region is around 7.5 Mtep and represents a cost for final consumers of 3.5 million Euro of which 40% corresponds to transport costs. Around 50% of total energy demand is constituted by oil, 23% by gas and 6% by coal. Electricity represents a 14% of the total and renewable energies are still below 7%. Most fossil fuels are imported from Spain and the Rest of the world as there is an insignificant extraction of fossil fuels in the region.

In this paper we aim to evaluate the regional impacts of Spanish climate policy by analyzing the economics effects of CO_2 emissions reduction in the Basque Country in an AGE framework with specific attention to environment-energy-economy interactions.

The article is organized as follows. In Section 2 we present the characteristics of the AGE model used in the analysis. Section 3 discusses the main results for the macro economy, sectoral composition, energy use and marginal abatement costs. In Section 4 we conduct a sensitivity analysis to assess the robustness of the model with respect to the main model parameters; and, finally, Section 5 contains some final remarks.

2. CHARACTERISTICS OF THE MODEL

2.1. General description of AGE models

The framework we use for our model is multi-sectoral, static, applied general equilibrium (AGE) modeling for a small open economy. AGEs are essentially empirical versions of the Arrow-Debreu general equilibrium structure. These models consider the fully closed economic cycle and are suitable when indirect effects for the policy to be analyzed are relevant. For a good introduction into AGE modelling see Ginsburgh & Keyzer (1997) and Shoven & Whalley (1992).

General equilibrium can be described by a set of economic agents, households and firms, that demand and supply different goods. AGE model results are the solution of a non-linear equations system where 1) zero profit, 2) income balance, and 3) market clearance conditions hold simultaneously and for all agents. According to neoclassical theory assumptions, agents behave rationally, take prices as given and solve their own optimization problem. Producers operate under full competition and maximize profit subject to current technology. Under constant returns to scale net profits are zero; the value of output has to equal the value of all inputs used (zero profit condition). Consumers have an initial endowment of factors and maximize utility subject to the budget constraint; the value of income must equal the total value of expenditures (income balance condition). Finally, equilibrium is characterized by a set of equilibrium prices such that demand equals supply for all commodities simultaneously (market clearance condition). In this situation agents cannot do better by altering their behaviour. The zero homogeneity of demand functions and the linear homogeneity of profits in prices imply that, in the general equilibrium context, only relative prices matter. Hence, a numéraire has to be chosen to fix the absolute price level; in our model this role is played by the consumer price index.

2.2. Description of the CGE model for the Basque country

The economy is disaggregated in 27 sectors, including four energy sectors. Sectors and goods correspond: each sector produces one unique good and vice versa. Apart from the energy carriers, we consider two other production factors; labor and capital. Private households are aggregated into a representative consumer; a government sector is specified that deals with taxes, consumption of public goods and implements environmental policy, and finally, trade takes place with two regions; Rest of Spain and Rest of the World. The general structure of the model is represented in figure 1 and the main elements are briefly described in the subsections below. The model is solved using GAMS/MPSGE (Rutherford, 1999)[1] and a complete specification of the equations and notation can be found in Appendices.

2.2.1.Producers

Producers maximize profits subject to a technology constraint (production function). They need intermediate inputs, labor, capital and CO_2 emissions permits for their activity, and receive income from selling their products after paying the corresponding taxes.

[1] MPSGE is a programming tool that runs in GAMS platform and solves general equilibrium models in a mixed complementarity (MCP) format.

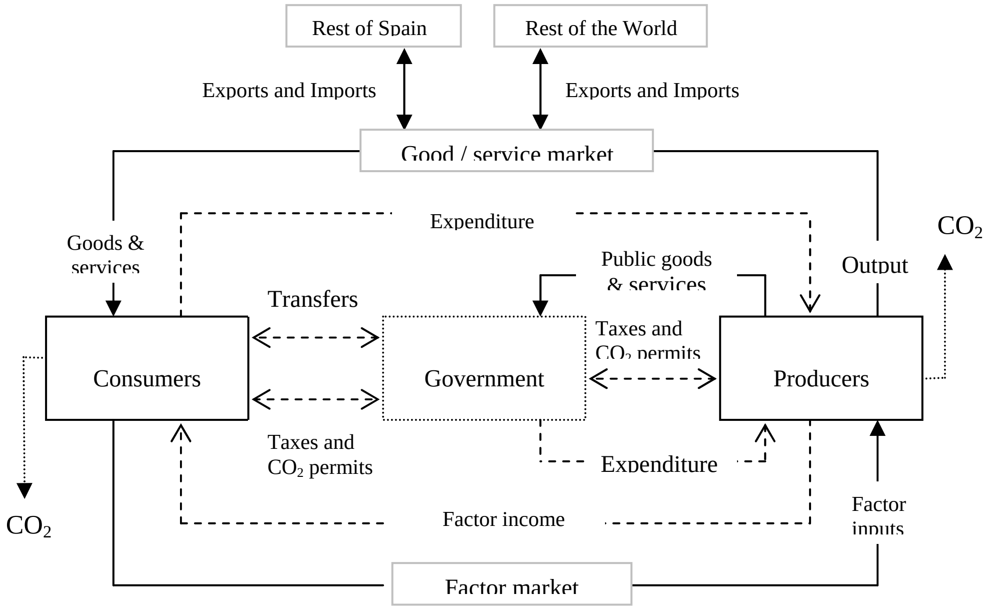

Fig. 1 General structure of the model

In most AGE models technology and substitution possibilities are described by a nested production structure in which constant elasticity of substitution (CES) functions are hierarchically combined. This article assumes the same production structure as in the GTAP-E model (Rutherford & Paltsev, 2000a, 2000b). CO_2 emission permits are considered a necessary input in production and emissions are generated in fixed proportion to the use of coal, oil and gas.

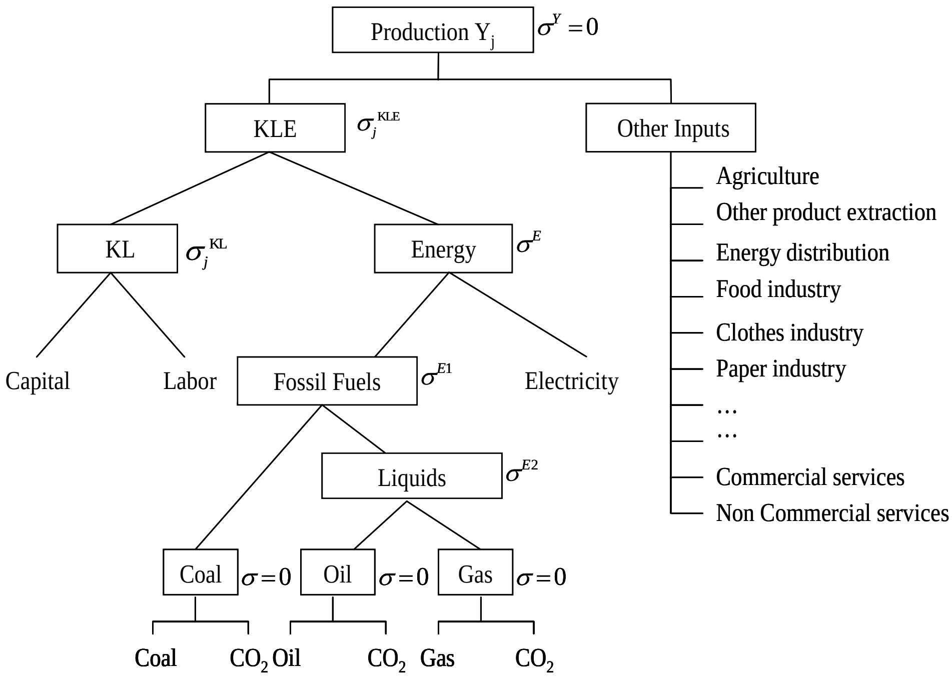

Fig.2: CES Nested Production Structure

The production structure is represented in figure 2. The parameters (σ), at the left side of each composite, represents the substitution elasticity to produce this composite between the inputs right below within a CES function[2]. Elasticities are the same for all sectors except in the case of the elasticity between Energy and Capital-Labor (σ_j^{KEL}) and between Labor and Capital (σ_j^{KL}), where sectoral differentiation is important. The values of all the elasticities can be found in Appendices.

2.2.2.International Trade

International trade is modelled following two common assumptions. First, we adopt the 'small open economy' assumption, meaning (a) that the domestic market is too small to influence world prices and (b) that the world market can satisfy all the importing and exporting requirements of the domestic economy. Secondly, we adopt the 'Armington assumption' (Armington, 1969) which considers domestic and foreign goods as imperfect substitutes. This approach helps to explain the observed differences in domestic and foreign goods prices and, practically, avoids an outcome with full specialisation. This is implemented, as in the production function, within a CES framework as illustrated in figure 2.

As the policy simulated in the model is part of a national policy for Spain, it is natural to assume that there are no possibilities to substantially change the trading relations with the Rest of Spain. We implement this by adopting trade elasticities between Basque Country and Rest of Spain equal to zero. In contrast, there are possibilities to change trade patterns with the Rest of the World. This is incorporated by positive trade elasticities between the composite of Basque and Rest of Spain with the Rest of the World. The structure of trade function is represented in figure 2.

Finally it is necessary to specify a closure rule for economic flows. In this model, we consider the common assumption that the trade surplus, i.e. the excess of exports over imports, is financed by savings on the consumer's budget. Given that most trade from the Basque country is performed with other regions that have adopted the Euro currency, we adopt the (ad

[2] For instance, Capital and Labor can be mutually substituted with the elasticity σ_j^{KL} to form the KL composite. Similarly, KL and Energy can be also substituted with the elasticity σ_j^{KEL} to produce the KEL composite. In the case of emissions and CO_2 permits a zero elasticity implies that for each unit of emissions a permit is required.

hoc) assumption that the trade deficit adjusts to clear the trade market while the exchange rate is constant.

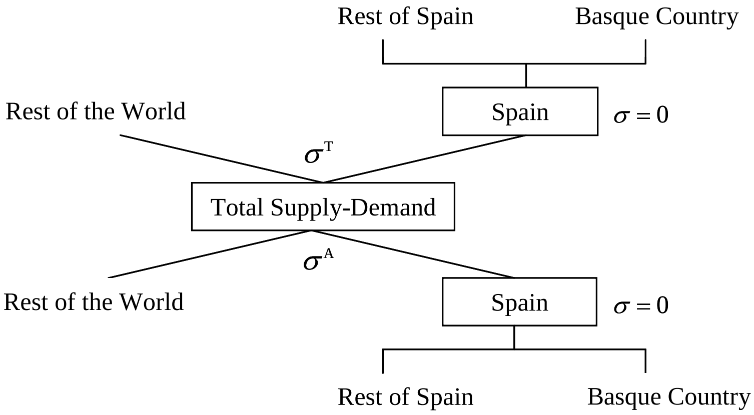

Fig.3. CES Nested Trade Structure

2.2.3.Consumers

We consider a representative consumer that maximizes utility subject to the budget constraint. Utility is formed in a CES function between consumption composite and leisure, as illustrated in figure 4. The consumption composite is similarly formed with a CES function of energy and non energy goods. Consumers get income by selling their endowments of labor and capital and from lump sum transfers from the government. As producers, they need to buy emission permits in fixed proportion to the use of fossil fuels. Savings are used to finance investment and to cover the trade surplus.

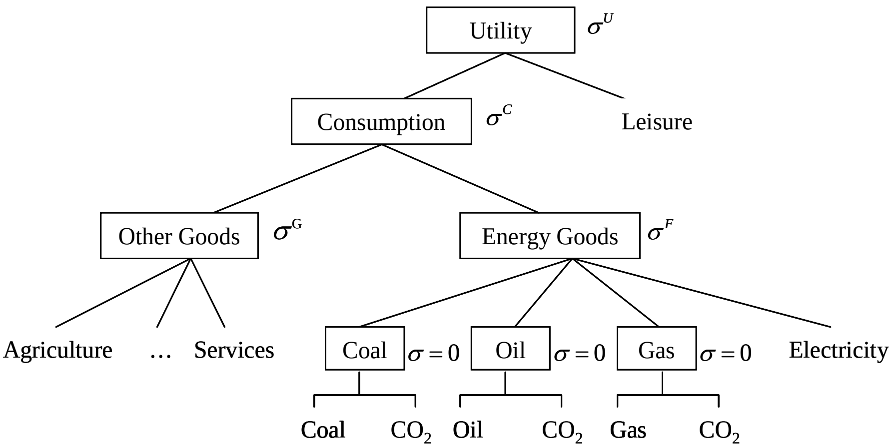

Fig.4: CES Nested Utility Structure

2.2.4.Government

The government collects taxes on production, labor and consumption, and auctions the emission permits. Revenues are spent on public consumption and transfers to the consumers so that public deficit remains zero. We assume that any change in government income, due to the extra income received from the emission permits, is balanced with increasing lump sum transfers and, hence, the size of public consumption and public deficit remains constant. This implies that utility from public goods is constant and changes in utility only stem from changes in private consumption (equal-yield assumption). For simplicity we consider there are no explicit financial transfers between Basque and Spanish government and all relations go through the trade balance.

2.2.5.Labor and Capital Supply

Labor supply is endogenized using the labor-leisure choice in the utility function. The representative consumer is endowed with an exogenous amount of time to share between labor and leisure. More time dedicated to labor means more revenues to be used for consumption.

Another important feature concerns capital flows and the investment decision specification in a static AGE model. The level of investment in a real economy depends upon interest rates, depreciation, and on previous capital stock but, in a static context, this cannot be fully incorporated in the model. Therefore, we assume that consumers are endowed initially with a certain capital stock that adjusts following the condition that in equilibrium the price of investment should be equal to the rental price of capital delivered by that invesment (cf. Hayashi, 1982). In this way, the investment decision is consistent with the return to capital in the counterfactual analysis.

2.3. Data and model calibration

The model is calibrated using a social accounting matrix (SAM) for the Basque Country built from the I/O Tables (EUSTAT 2000, see Appendices). In the calibration process, values are given to parameters such that the model can reproduce the SAM as an equilibrium solution. This replication represents the initial allocation of resources, the so called benchmark equilibrium.

For a comparative static analysis we need data for the agents' responses to changes in circumstances. These reactions are given by elasticities and govern the transition to a new equilibrium solution or counterfactual equilibrium. We use data from a literature selection made for the Spanish economy by Gomez, Faehn, & Kverndokk (2004) and from GTAP-E model (Rutherford & Paltsev, 2000b).

Physical emission coefficients from coal, oil and gas for each sector are provided by Eurostat Statistics (Eurostat, 1991) and are adapted with Spanish energy price data for producers and consumers. Another adjustment has been carried out on these coefficients to account for the amount of fossil fuel that is not used for combustion, as is the case in some industries and especially in the chemical sector (see Appendices). It is relevant to note that there is no domestic extraction of coal, oil or gas in the Basque country.

2.4. Implementation of environmental policy

Environmental policy in the Basque Country is modeled within a system of marketable pollution permits. Emission permits are exchanged between Basque economic agents, but the trade structure proposed imitates a situation in which similar climate policy objectives are also implemented within Spain; thus, the Basque Country is not able to transfer it's environmental problems to the rest of Spain (cf. Dellink, 2005).

The government fixes the number of permits to reflect the emission target and auctions them in the market. As there is perfect information, they are assigned efficiently at the equilibrium price. Theoretically this approach has the main advantages that it is cost effective, i.e. targets are reached at the minimum cost, and that is effective, i.e. government can be sure targets are achieved by controlling the number of permits. Furthermore, the tradable pollution permits approach is a natural way of modelling optimal abatement policies in an AGE structure; permits can be treated as another commodity with its own equilibrium price where demand equals supply and the market clears (cf. Dellink, 2005).

In the benchmark, permits are distributed for free according to benchmark emissions by agent; there is no scarcity and the price of permits in the market is zero. In the counterfactual policy scenarios the government auctions a limited number of permits. The substitution possibilities between inputs govern the way the model adapts to policy implementation and the competition between the polluters for the scarce permits ensures that reduction is achieved at minimum cost. These adaptation effects can be summarized by the variations in the: i) mix of energy use: from CO_2 intensive fuels to cleaner ones; ii) production structure: substitution between inputs used for production; iii) economic structure: increasing the production of cleaner sectors and decreasing the dirtier ones and, finally, iv) scale of economy: reducing economic activity.

Other abatement options such as end of pipe or process oriented technologies are not considered because we suppose that they are more costly than input substitution and fuel switch. This assumption is appropriate for short term policy analysis, simplifies calculations considerably and is common in most of the major energy-economic models (Bohringer & Rutherford, 2002; Manne et al., 1995; Nordhaus, 1993; Whalley & Wigle, 1991). Finally, it should be noted that we are assessing exclusively the cost of abatement and not the benefits from lower emissions in the form of lower environmental damage or higher amenity values. This analysis is therefore limited to a cost-effectiveness analysis for the short term and we cannot claim whether the targets analyzed are efficient.

3. RESULTS

The analysis focuses on the economic impacts of CO_2 abatements in steps of 5% up to a limit of 30%. Spain, including the Basque Country, is allowed to increase their greenhouse gases emission up to 15% according to the Kyoto protocol, but by 1999 emissions had increased by 29% (INE, 2002). This put the Kyoto reference target around a reduction of 15% in emissions from the base year. As it is not clear what the contribution of the Basque country in this national reduction effort will be, we explore a range of required emission reductions from 5% to 30%.

The analysis starts with a discussion of the general effects and then turns the attention to some specific issues such as changes in energy consumption and sectoral production levels. The marginal abatement cost curve of progressive emission reductions is another interest result that this analysis can offer. AGE models use some parameters that are uncertain and, hence, the study is complemented with a systematic analysis of the sensitivity of the model with respect to the elasticities of substitution parameters to gain insight in the possible variations in results.

3.1. General results

The effects on macro-economic variables indicators are shown for each level of emission reduction in figure 5. As a general overview, we observe a decrease of all variables for all levels of emission reductions. This result supports the idea that there are no free options to cut down emissions. It is also important to notice that higher levels of required emission reduction lead to larger decreases in variables and, hence, economic costs increase more than proportionately with increasing environmental policy levels; this is due to the non-linear functions in the model.

In Table 1 we present a general overview of the results for three levels of reduction; 10%, 20%, and 30%. Two indicators are presented to reflect the macro-economic impact of the policies: utility and GDP. Utility is a good indicator of the welfare costs of the policy; welfare changes can be calculated as a Hicksian Equivalent Variation (EV) measure of the policy, as the AGE distinguishes changes in quantities and prices. It should however be stressed that the benefits of the policy, in terms of increased environmental quality, are not taken into account, and hence the utility losses only represent the cost-side of changes in total welfare. Utility decreases with 0.2% when emission levels are reduced by 10%, but welfare losses increase to 0.7% and 1.2%, respectively, as the policy becomes more stringent. GDP shows a reduction of 0.6%, 1.4% and 2.3%, respectively. As consumption levels decrease less than investment, it is not surprising that GDP losses are larger than utility losses. The model is static so we do not account for the impact that a smaller level of investments has on future economic growth.

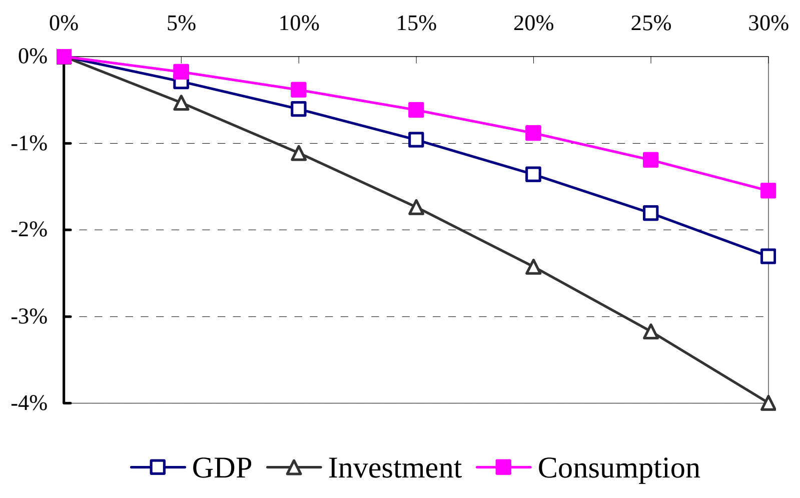

Figure 5: GDP, Investment and Total Consumption reduction for different CO_2 abatement levels

From the results it can be inferred that production is more affected than consumption, because the demand for produced goods by other production sectors is reduced, but especially because the use of goods for investments decreases substantially. Imports and exports generally go in the same direction, but there may be differences at a sectoral level. The increase in imports is somewhat smaller than the increase in exports, indicating that the trade surplus increases.

Table 1: General Results for abatement levels compared to benchmark 1995

	10%	20%	30%
Macroeconomics results (% volume variation)			
Utility	-0,21	-0,51	-0,94
GDP	-0,61	-1,36	-2,31
Private Consumption	-0,38	-0,88	-1,55
Savings/ Investments	-1,11	-2,42	-4,00
Production	-1,07	-2,30	-3,74
International Trade results (% volume variation)			
Imports	-1,36	-2,91	-4,70
Exports	-1,45	-3,11	-5,03
Trade Balance	-4,60	-10,52	-17,80
Economic Structure [1] (% volume variation)			
Sectoral Production Agriculture	-0,76	-1,72	-2,95
Sectoral Production Industry	-1,46	-3,13	-5,08
Sectoral Production Services	-0,57	-1,25	-2,05
Private Consumption Agriculture	-0,49	-1,15	-2,04
Private Consumption Industry	-0,72	-1,65	-2,87
Private Consumption Services	-0,22	-0,51	-0,91
Energy [2] (% volume variation)			
Total Energy Use	-5,50	-11,45	-17,96
Energy consumption Producers	-7,72	-15,74	-24,11
Energy consumption Consumers	-2,42	-5,49	-9,41
Prices (% variation from index price 1995= 1)			
Price of Capital	1,00	1,00	1,00
Price of Labor	0,99	0,98	0,97
Permit Price (euro / ton. CO2 eq.)	13,60	32,61	60,16
Climate Policy and Closure rules			
Total CO2 Emissions (% volume variation)	-10,00	-20,00	-30,00
Exchange rate index (% variation from index price 1995 = 1))	1,00	1,00	1,00
Goverment Consumption (% volume variation)	0,00	0,00	0,00

[1] All sectors are grouped in three categories: Agriculture (1), Industry (2 a 16) and Services (17 a 22)
[2] Energy groups the consumption of coal, oil, gas and electricity.

The environmental policy has a substantial impact on all economic sectors. As many sectors use fossil fuels for their activity, changes in economic structure are considerable. This can be seen by the big impacts on agricultural and industrial production and the smaller impact on the services sectors. In consumption the impact levels are much smaller and more evenly spread across sectors. This result also shows that consumers can limit their need to adapt their consumption patterns, while the production structure is adapted substantially to comply with the more stringent environmental policy.

It is obvious that the largest source of emission reduction comes from the reduction in the use of fossil fuels. Total use of energy decreases by 5% for a reduction of 10% in CO_2 emissions and by 18% for a reduction of 30%. This approximately reflects that changes in the fuel mix and energy savings both are critical in achieving the required emission reductions. Consumer's reduction of energy use is much higher than the reduction of energy use by producers, reflecting the fewer possibilities for consumers to switch between different energy carriers as compared to producers.

3.2. Sectoral results

Multi-sectoral AGE´s are an appropriate tool to identify how policy changes affect different sectors. Any shock in the initial general equilibrium situation will result in a different allocation of the resources and, consequently, sectors will be affected in different ways. These effects are much more diverse than the macroeconomic results; dirty sectors are affected more than clean ones and some sectors may even benefit from environmental policy. Figure 6 shows the results for sectoral domestic production for a reduction in emissions of 10%, 20% and 30% level.

Domestic production decreases for almost all sectors and for all levels of CO_2 abatement. The group of sectors that is severely affected is, not surprisingly, the group of highly polluting and energy-intensive industries. This includes not only the energy sectors themselves, but also for instance the transport sectors. The impact is especially severe for the oil refinery industry. These impacts are a combination of changes on the supply side, where high emission intensities make the production process more costly, and the demand side, where higher prices for goods induce demand reductions. Transport by water is more affected than other transport sectors because the high emission intensity of the sector; though in absolute terms this is a

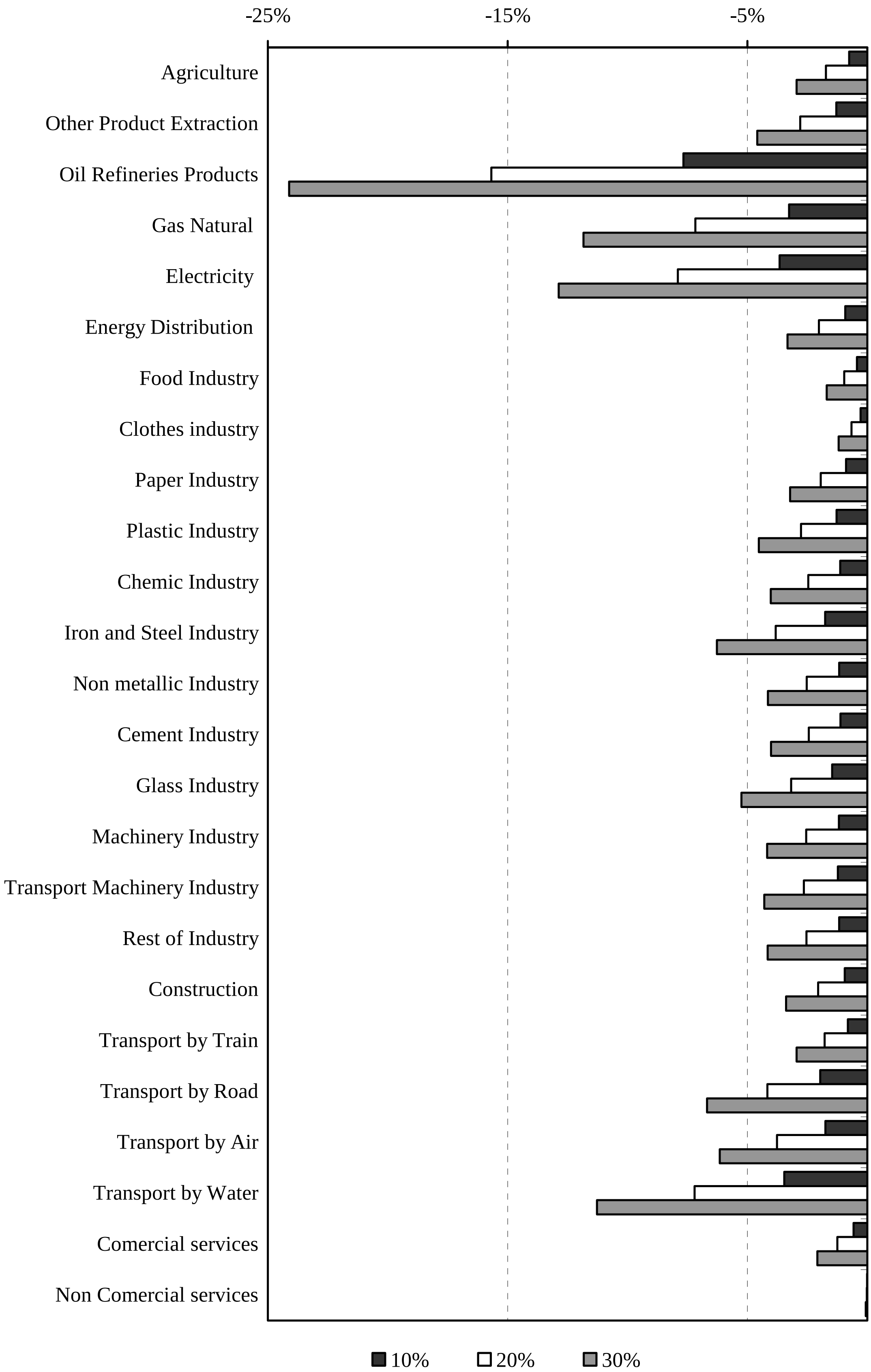

Figure 6: Sectoral Production volumes changes (%) for different abatement levels

very small sector, and the influence on the rest of the economy is very limited (see table A.2). Agricultural production is reduced moderately, but this effect would be much bigger if other GHGs had been taken into account, as it is very intensive in methane (CH_4) and nitrous oxide (N_2O) emissions.

The service sectors are relatively well-off as the proportions of non polluting production factors, labor and capital, are much higher than in other sectors. Moreover, the services sectors represent around 40% of total economic production (see Appendices). In general, these results indicate a restructuring of the economy from energy and dirty industrial sectors toward the services sectors.

The decline in the total use of energy is substantial, but there are important differences between coal, oil, gas and electricity. Figure 7 illustrates that use of coal is reduced much more than the use of the other energy carriers and a 30% required reduction in emissions induces a reduction in coal use of 42%. Oil use is reduced less than coal, but more than gas and electricity. These changes in fuel mix clearly reflect the underlying differences in CO_2

emission intensities of the different energy carriers (cf. Appendices). Note that the reduction in electricity use is the result of an indirect effect: the sector itself is not coupled to emissions, but only through the use of fossil fuels in the production of electricity.

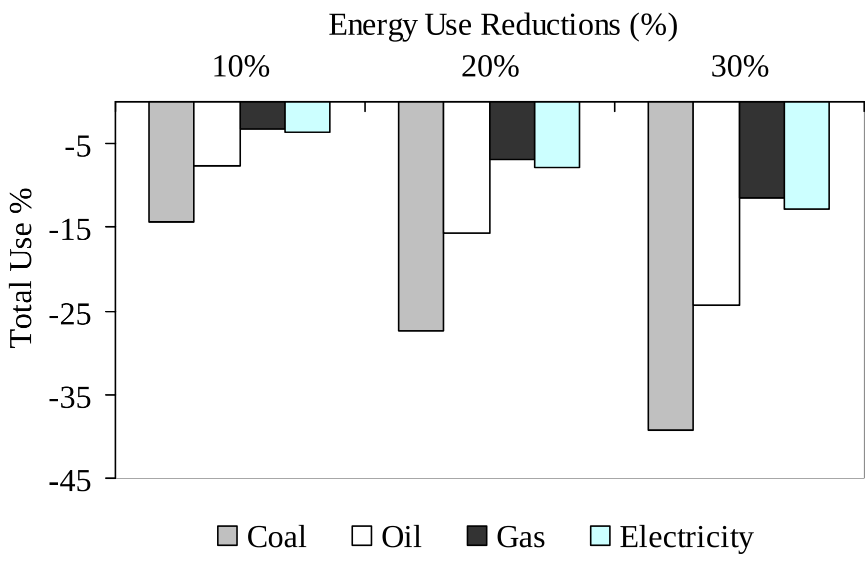

Figure 7 Total changes in energy use for different abatement levels

Results in consumption can be found in Figure 8. The consumption of products from Oil refineries shows a large reduction that comprises changes in heating from oil to other

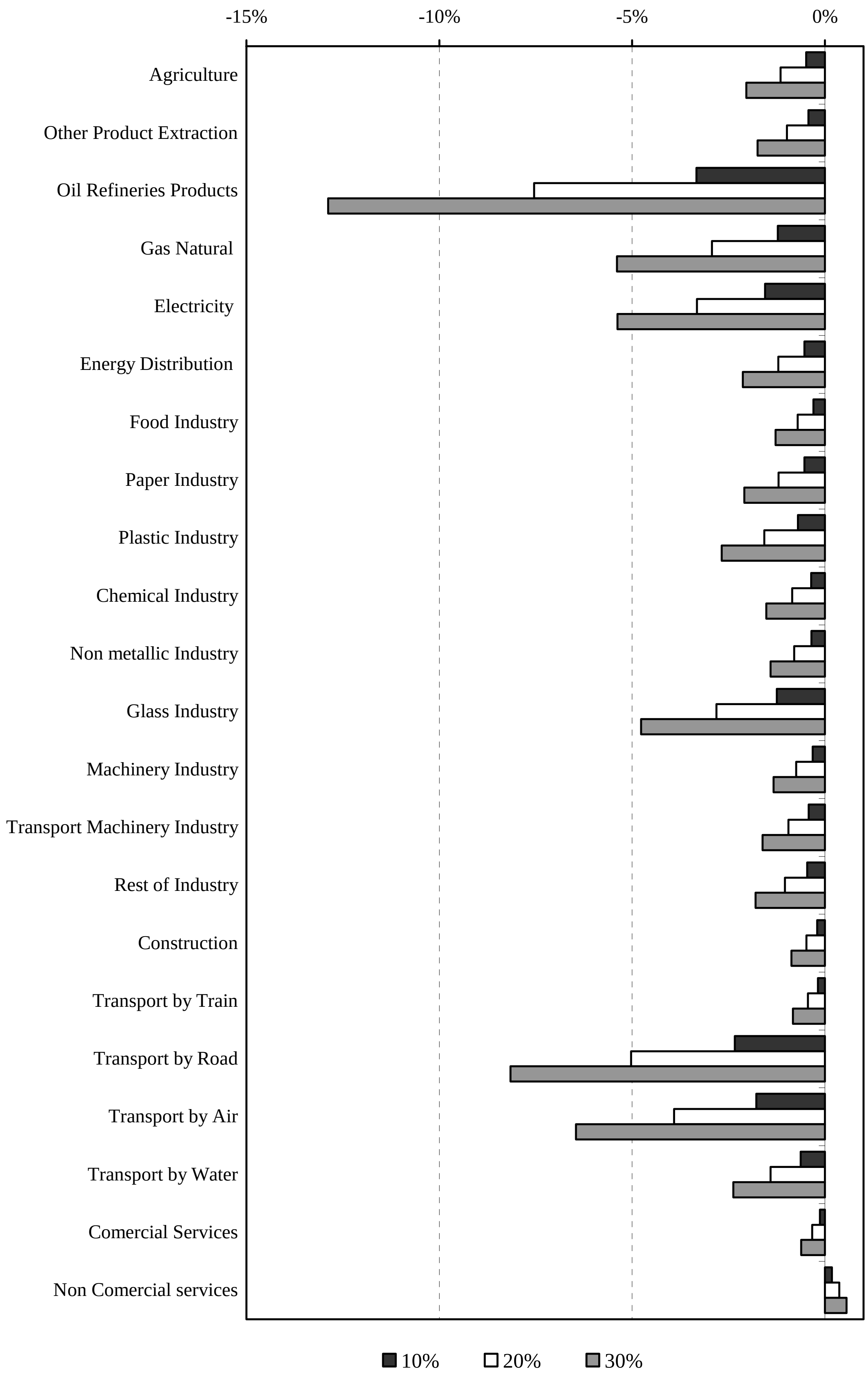

Figure 8: Sectoral Consumption volumes changes (%) for different abatement levels

alternatives. Consumption of goods that are CO_2-intensive in production also reduces relatively much, induced by the price increases of these goods and services. Reductions in the consumption of services remain limited, and the non-commercial services sector even increases very slightly. These results indicate that consumption patterns change to some extent towards cleaner products.

3.3. Marginal abatement cost

AGE models can give us the implicit marginal abatement costs (MAC) at different levels of emission reduction (Ellerman and Deceaux, 1998). As solutions found for each policy level are cost-effective, emission permit prices reflect marginal abatement costs from a macroeconomic perspective. The advantage of this way of calculating abatement cost curves is that both the direct and indirect costs are incorporated in the estimate, whereas bottom-up oriented studies of marginal abatement costs tend to ignore indirect effects (cf. Dellink, 2005). Nonetheless, the quality of the MAC curves depends on the alternative options for emission reduction that have been introduced in the model. In line with other climate-economy models, we ignore end-of-pipe options as they are prohibitively costly for the range of emission reductions we investigate. Nonetheless, this implies that the MAC we obtain cannot easily be extrapolated to more far-reaching emission reduction targets. The marginal abatement cost curve obtained is presented in Figure 9 in Euro per ton of CO_2.

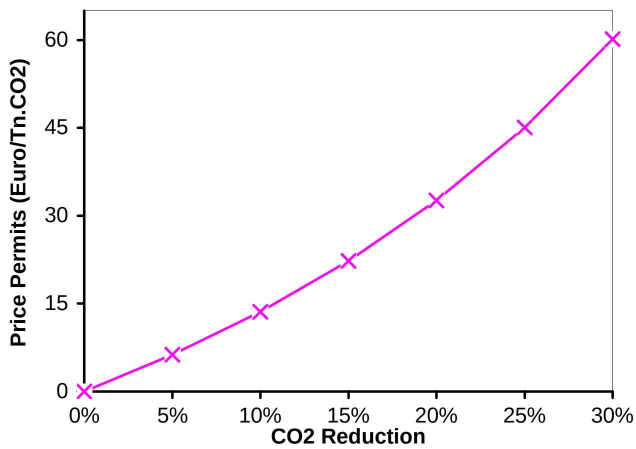

Figure 9: Marginal abatement cost for different abatement levels

The marginal cost for the reduction range considered is between 0 and 60 Euro per Ton of CO_2, in line with other studies (Weyant, 2004). The price of emissions increases more than proportionally for stricter environmental policy; marginal abatement costs increase more and more rapidly as cheaper options are gradually exhausted. For a reduction of 15% in emission, similar to the Kyoto reference target, the cost per ton of CO2 would be 21 Euro per ton of CO_2. These results are good reference points for policy makers that like to know ex-ante what approximately the price of emission permits could be in a permit market system for a unilateral environmental policy within the Basque Country, or that want to implement a carbon tax.

3.4. Unilateral versus multilateral policy

The environmental policy investigated above is implemented unilaterally in a regional economy, though the trade setting with respect to the Rest of Spain mimics a similar Spanish policy. However, climate change policy depends highly on global agreements and on international (European) emission trading market systems. In this section we explore the impacts of climate policy on a regional economy in a context in which the environmental policy is implemented multilaterally for all countries the Basque region trades with.

The Armington specification on trade allows some substitutability between domestic and foreign goods, and we assumed that world market prices are constant. As the model does not specify explicitly other countries, it is necessary to make an approximation that resembles this situation by assuming that relative world market prices change in the same way as relative domestic prices do (Dellink, 2005). This is true if sectoral impacts of environmental policy are similar across countries and means that import and export shares in trade goods will not change. This specification can be implemented by assuming that Armington (σ^A) and Transformation (σ^T) elasticities on trade are zero; in this case, there is no possibility of substitution between domestic and foreign goods and both are demanded in fixed proportion.

The results obtained with the multilateral specification differ from those observed in the unilateral one. As there is no possibility to specialize on clean goods, especially consumption patterns are affected more severely. The welfare costs are around two thirds higher in the multilateral scenario as illustrated in Figure 10. This results is often found in AGE models (Gerlagh et al., 2002), contradicts the common argument that environmental policy negatively affects international competitiveness and shows that environmental friendly specialization can turn environmental policy into an opportunity or advantage (Greaker, 2003).

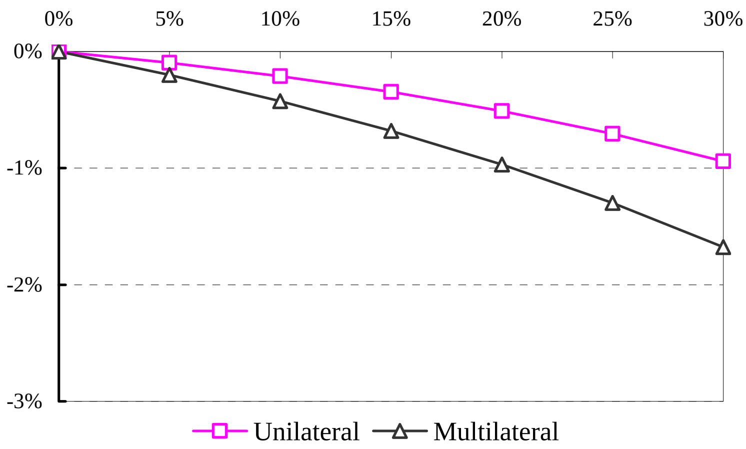

Figure 10: Welfare change (%) for different abatement levels in a unilateral and multilateral scenario

4. Sensivity Analysis

Sensitivity analysis is essential for testing the robustness of any model. Calibration with systematic sensitivity analysis is the most common practice with AGE models as it gives a good measurement of the cost and deviations from variations in parameter values. We have performed sensitivity analyses on all the elasticities used in the production, trade and utility functions, for the case where the emissions are reduced by 15% compared to the benchmark. Two simulations are considered; in the low simulation, the value of one of the elasticities is the half of the base case value and in high simulation the value is doubled.

The results in figure 11 illustrate the range of variation in GDP for the different simulations. GDP turns out to be sensitive to the top level in the nested CES structure, as is the case of Energy & Value added and Consumption & Leisure. Moreover, the trade elasticities have a substantial impact, in line with the analysis of the multilateral specification above. The elasticity between Labor and Capital is also significant as value added represent a very high proportion of all the inputs used in production. The rest of elasticities do not influence considerably the final results.

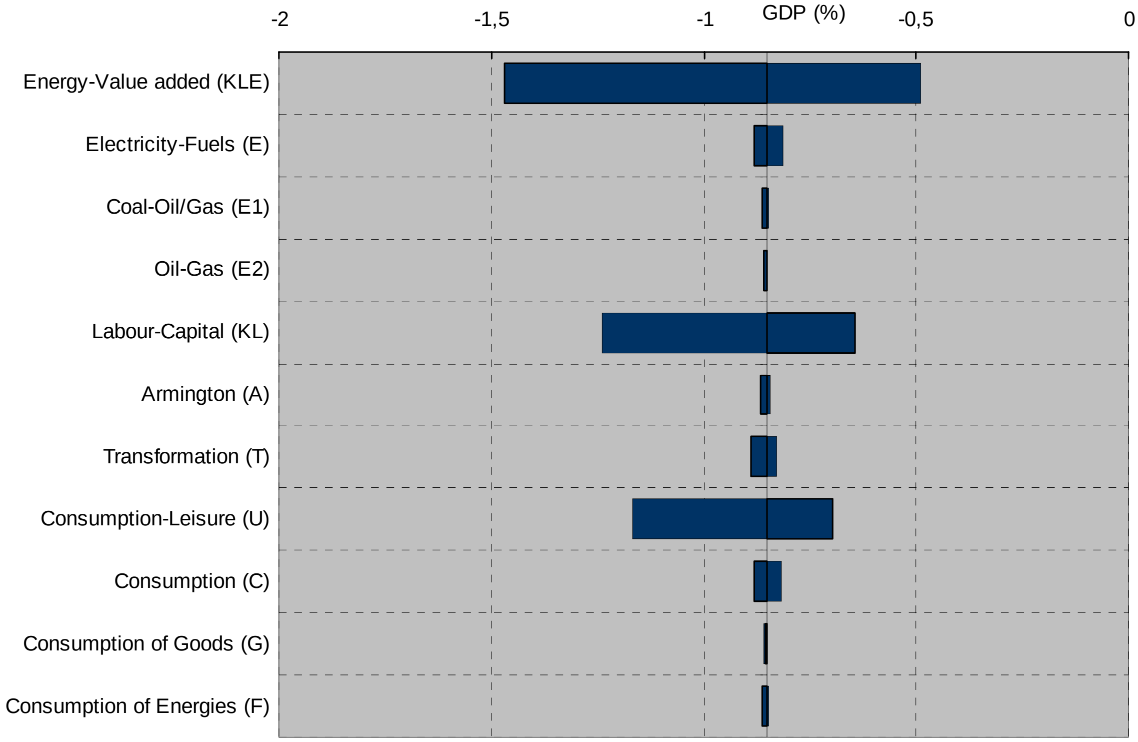

Figure 11: Elasticities Sensitivity analysis results for an abatement level of 15%

5. CONCLUSIONS

In this article, the economic impact of CO_2 abatement policies for the Basque Country is analyzed. We use a static multi-sectoral applied general equilibrium (AGE) model with specific attention to energy use and CO_2 emissions. The instrument used to implement environmental policy is a tradable emission permit system. The model quantifies the effects on macro-economic variables, energy consumption, and sectoral production activity, and provides insights into the least cost effects for different emission reduction goals.

Some caveats should be considered in order to put these results in perspective. Concerning the model, it should be mentioned that the absence of consideration of end-of-pipe abatement options restricts the appropriate scope of the analysis to environmental policy targets that are not too far-reaching. Moreover, it is important to remind that the lack of accounting of the benefits of environmental policy limits a proper welfare analysis. There are also caveats concerning the data used; this is the case for the elasticities of substitution, for which an econometric estimation would be valuable. Finally, the details of the interactions between the Basque Country and the Rest of Spain can be improved. This includes among others financial transfers, permit trading between both regions and perhaps even a full disaggregration of the

Basque economy in the GTAP or GTAP-E database and model may be envisaged. Any progress on these issues will lead to a more realistic model and better simulations results.

There are several conclusions that can be obtained from this empirical analysis. A policy to cut CO_2 emissions in the Basque Country will have to face some costs. However, there are many possibilities in terms of fuel substitution in order to make this reduction not so costly: a reduction in emissions of 15% induces a decrease in GDP of approximately 1%. The required emission reductions are achieved through a combination of fuel switch, away from coal and oil, and a restructuring from the ‘dirty’ energy and industrial sectors toward the ‘cleaner’ services sectors. Trade is an important factor for keeping the costs low; the welfare costs are substantially higher if the circumstances on the international markets do not allow a specialization of the domestic economy in clean production. Finally, it is estimated that the price of CO_2 emission permits reaches just over 60 Euro per ton for the more stringent policy target of 30% emission reduction.

The purpose of this analysis was to contribute to a better understanding of the economic impacts of climate change policies applied to Basque Country. As we have seen, the economic cost of pollution reduction is limited by the substitution possibilities and fuel switch options, but some sacrifice has to be made. We hope these results will assist in a better informed climate policy action in the Basque Country, considering the trade-offs between economic costs and environmental quality.

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APPENDICES

A1. Model Equations

Production

Production function for goods [3] $\forall j \in (1,...,\mathrm{J})$

$$Y_j = CES\left(Y_{1,j}^{ID},...,Y_{J,j}^{ID};K_j;L_j;E_j^P : \sigma^Y, \sigma^{KLE},...,\sigma^{E2}\right)^4 \quad \text{(Ec.1)}$$

Zero profit condition $\forall j \in (1,...,\mathrm{J})$

$$\left(P_j - \tau_j^P\right)\cdot Y_j - \left[P_j \cdot Y_{jj,j}^{ID} + P_K \cdot K_j + \left(P_L + \tau_j^L\right)\cdot L_j + P_E \cdot E_j^P\right] = 0 \quad \text{(Ec.2)}$$

Trade

Total supply from import and production for goods [5] $\forall j \in (1,...,\mathrm{J})$, $\forall r \in (1,...,R)$

$$Y_j^{TS} = CES\left(Y_j, M_{j,r};\sigma^A\right) \quad \text{(Ec.3)}$$

Domestic demand and export from total demand $\forall j \in (1,...,\mathrm{J})$ $\forall r \in (1,...,R)$

$$Y_j^{TD} = CET(Y_j^D, X_{j,r} : \sigma^T) \quad \text{(Ec.4)}$$

Closure rule on trade $\forall j \in (1,...,\mathrm{J})$ $\forall r \in (1,...,R)$

$$\sum_{j=1}^{J}\sum_{r=1}^{R} P_X\left(M_{j,r} - X_{j,r}\right) = XD \text{ with } P_X \text{ fixed.} \quad \text{(Ec.5)}$$

Market balance

Goods markets balance $\forall j \in (1,...,\mathrm{J})$

$$Y_j^{DD} = \sum_{jj=1}^{J} Y_{j,jj}^{ID} + C_j + G_j + I_j \quad \text{(Ec.6)}$$

---

[3] The nesting structure for production function is represented graphically in figure 2.
[4] CES functions have the following structure for the case of two level of nesting and two inputs: In the first level $Y = CES(X_1, X_2;\sigma) = (a_1 X_1^{\sigma-1/\sigma} + a_2 X_2^{\sigma-1/\sigma})^{\sigma/\sigma-1}$ and in the second level $X_2 = CES(X_3, X_4;\psi) = (a_3 X_3^{\psi-1/\psi} + a_4 X_4^{\psi-1/\psi})^{\psi/\psi-1}$, where a_1, a_2, a_3 ,a_4 are parameters and σ , ψ represent the elasticities of substitution between the inputs
[5] The nesting structure for trade function is represented graphically in figure 3.

Capital markets balance $\forall j \in (1,...,\mathrm{J})$

$$\sum_{j=1}^{J} K_j = \overline{K} \qquad \text{(Ec.7)}$$

Labor markets balance $\forall j \in (1,...,\mathrm{J})$

$$\sum_{j=1}^{J} L_j = \overline{L} \qquad \text{(Ec.8)}$$

Savings/investments balance $\forall j \in (1,...,\mathrm{J})$

$$S = \sum_{j=1}^{J} P_j \cdot I_j + XD \qquad \text{(Ec.9)}$$

Consumer

Utility function representative consumer [6] $\forall j \in (1,...,\mathrm{J})$

$$U_H = CES(C_1,...,C_J; LS; E^C : \sigma^U,...,\sigma^F) \qquad \text{(Ec.10)}$$

Income balance representative consumer $\forall j \in (1,...,\mathrm{J})$

$$\left[P_K \cdot K + P_L \cdot L + T\right] - \left[\sum_{j=1}^{J}\left(P_j + \tau_j^C\right)\cdot C_j + P_E \cdot E^C + S\right] = 0 \qquad \text{(Ec.11)}$$

Government

Utility function government $\forall j \in (1,...,\mathrm{J})$

$$U_G = CES(G_1,...,G_J) = \overline{U_G} \qquad \text{(Ec.12)}$$

Income balance government $\forall j \in (1,...,\mathrm{J})$

$$\left[P_E \cdot (E^P + E^C) + \sum_{j=1}^{J}(P_L \cdot \tau^L \cdot L_j + P_j \cdot \tau_j^C \cdot C_j + P_j \cdot \tau_j^P \cdot Y_j)\right] - \left[\sum_{j=1}^{J} P_j \cdot G_j + T\right] = 0 \qquad \text{(Ec.13)}$$

Environment

[6] The nesting structure for utility function is represented graphically in figure 4.

CO2 Emission on production $\forall j \in (1,...,\mathrm{J})\ \ e \in (coal, oil, gas)$

$$E_j^P = \sum_{e=1}^{3} \alpha_e \cdot Y_{e,j}^{ID} \qquad \text{(Ec.14)}$$

CO2 Emission on consumption $\forall j \in (1,...,\mathrm{J})\ \ e \in (coal, oil, gas)$

$$E^C = \sum_{e=1}^{3} \beta_e \cdot C_e \qquad \text{(Ec.15)}$$

CO2 Emission permits market balance $\forall j \in (1,...,\mathrm{J})$

$$E = \sum_{j=1}^{J} E_j^P + E^C = \overline{\text{target}} \qquad \text{(Ec.16)}$$

A2. Symbols

Indices

Label	Entries	Description
j, jj	1,...,J	Sectors, Intermediate Inputs or Goods
n	1,...,N	Non-Energy Sectors, Intermediate Inputs or Goods
e	Coal, Oil, Gas	Fossil Fuels
r	ROS, ROW	Regions; Rest of Spain and Rest of the World

Parameters

Label	Description
σ^Y	Substitution elasticity between energy-capital-labor and intermediate inputs
σ_j^{KEL}	Substitution elasticity between energy and capital-labor for sector j
σ_j^{KL}	Substitution elasticity between labor and capital for sector j
σ^E	Substitution elasticity between electricity and fossil fuels in production
σ^{E1}	Substitution elasticity between coal and liquid fossil fuels in production
σ^{E2}	Substitution elasticity between oil and gas in production
σ^U	Substitution elasticity between consumption and leisure
σ^C	Substitution elasticity between energy and non-energy goods
σ^F	Substitution elasticity between energy goods in consumption
σ^G	Substitution elasticity between non-energy goods in consumption

σ^A	Armington elasticity between domestic production and imports
σ^T	Transformation elasticity between domestic demand and exports
τ_j^L	Labor tax rate in sector j
τ_j^P	Production net tax rate in sector j
τ_j^C	Consumption tax rate in good j
T	Lump sum transfers between government and consumer
α_e	Production CO_2 emission coefficient of coal, oil and gas
β_e	Consumption CO_2 emission coefficient of coal, oil and gas

Variables

Label	**Description**
Y_j	Production in sector j
$Y_{j,jj}^{ID}$	Intermediate demand of input jj in sector j
Y_j^D	Domestic demand of good j
Y_j^{TS}	Total supply of good j
Y_j^{TD}	Total demand of good j
$M_{j,r}$	Imports of good j from region r
$X_{j,r}$	Exports of good j from region r
K_j	Capital demand by sector j
L_j	Labour demand by sector j
XD	Trade deficit with rest of the regions
U_H	Utility for Consumers
$\overline{U_G}$	Utility for Consumers
LS	Leisure
C_j	Private Consumption of good j
S	Savings
G_j	Public Consumption of good j
K	Capital supply
L	Labour supply
I_j	Investment in sector j

E_j^P	CO2 emissions by producer j
E^C	CO2 emissions by consumers
E	Total CO2 emissions
$\overline{target}$	CO2 emission targets
P_j	Equilibrium market price of good j
P_K	Equilibrium market price of capital
P_L	Equilibrium market price of labour
P_E	Equilibrium market price of emission permits
P_X	Equilibrium real exchange rate (price of foreign good)
P_I	Equilibrium price of investment

A3. Social Accounting matrix and data

We use a Social Accounting Matrix (SAM) to calibrate the model from Input-Output Tables (EUSTAT, 2000) with the following specific adaptations;

a) *Reallocation of secondary products row*: The Input-Output Table includes a row for reallocating secondary production (products that are produced by more than one sector and vice versa). Secondary production has been removed following the product-by-product approach (UN, 1999) and RAS (Bacharach, 1969) technique.

b) *Integration of physical energy data into Input-Output Table*: Energy sectors are essential in the model but in the original SAM some are aggregated with other activities (i.e. natural gas is mixed with hot water and steam, and oil products with nuclear products). Moreover, Input-Output Tables do not offer disagregation between quantities and prices which is important for calculation of CO_2 emissions. To overcome these problems, we obtained new energy demand rows for crude, coal, oil, gas and electricity multiplying physical data from energy balances (table A3) and energy prices (table A5). We include this new information in the SAM and correct the imbalance by minimizing the square distance between new and old SAM coefficients as shown in Rutherford & Paltsev (2000a).

c) *Closure of economic flows*: A SAM can be considered as an Input-Output Table extended with the closure of economic flows. The government sector accounts are balanced by transfers to / from consumers to account for any differences between public expenditures and revenues.

Finally, the *physical emission coefficients* from table A4 need to be adapted to be used in the model. As AGE models normally assume that all benchmark prices are equal to one (Harberger convention), it is necessary to multiply these values by energy prices of producers and consumers from the table A5. We consider CO_2 emission that mostly comes from combustion process and are calculated by multiplying the use of fossil fuels by some coefficients. However there are some uses of fuels that are not energetic, as is the case of many products in the chemic, plastic or cloth industry, and this effect is quite big to not be considered. For this reason is necessary to multiply emission coefficients by the corrective numbers presented in table A4 for chemic and industry sectors. Now emission coefficients can be used in the model and gives the CO2 emission presented for different sectors in table A2.

Table A1: SAM 1999 for Basque Country (mln. Euros)[7]

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18
Y1	676	0	0	0	0	0	0	0	-536	-35	-224	-22	-11	0	0	0	0	0
Y2	0	0	0	0	-7	-1	-39	0	0	0	0	0	0	-1	-2	-4	0	0
Y3	0	0	0	0	-929	-118	0	0	0	0	0	0	0	0	0	0	0	0
Y4	0	0	0	152	0	0	0	0	-7	0	-5	0	-17	-16	-158	-2	-3	-6
Y5	-31	0	0	-3	1449	0	-87	-3	-3	-1	-7	-6	-3	-5	-2	-2	0	-2
Y6	0	0	0	0	0	184	-31	0	-2	-1	-7	-5	-6	-39	-4	-2	-10	-7
Y7	-2	0	0	-2	-4	-1	672	-31	-16	-3	-60	-40	-48	-284	-17	-6	-10	-87
Y8	-2	0	0	-1	-10	-1	0	570	-5	-1	-16	-15	-21	-37	-21	0	-9	-19
Y9	-40	0	0	-1	0	0	0	0	1846	-10	-5	0	-10	0	0	0	0	-1
Y10	-3	0	0	0	0	0	0	0	-1	186	-1	-8	-1	-3	-2	0	-1	-2
Y11	-1	0	0	0	0	0	0	0	-54	0	1797	-19	-27	-10	-23	0	-15	-49
Y12	-2	0	0	0	0	0	0	0	-16	-1	-11	1847	-15	-1	-13	0	-1	-131
Y13	-22	0	0	-6	-16	-2	0	-53	-8	-7	-86	-627	1033	-40	-64	0	-13	-111
Y14	0	0	0	-1	0	0	0	0	-1	0	-1	-28	-13	2396	-743	0	-2	-939
Y15	0	0	0	-1	0	0	0	0	0	0	-2	-3	-1	-81	3445	0	-1	-465
Y16	0	0	0	0	0	0	0	0	0	0	-2	0	0	-3	-66	87	0	-1
Y17	0	0	0	0	0	0	0	0	-34	0	-1	-4	-1	0	-2	0	280	-16
Y18	-15	0	0	-5	-23	-3	-7	-55	-9	-2	-34	-34	-18	-83	-94	-1	-5	5309
Y19	-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-28
Y20	-6	0	0	-3	0	0	0	-2	-15	-1	-8	-5	-14	-31	-66	0	-4	-141
Y21	-1	0	0	-8	-4	0	-3	-25	-7	0	-9	-5	-5	-13	-21	0	-1	-27
Y22	0	0	0	0	0	0	0	0	-2	0	-4	-6	-8	-22	-11	0	-1	-8
Y23	-8	0	0	-18	-4	0	0	-2	-55	-4	-77	-54	-67	-77	-119	-1	-12	-134
Y24	-1	0	0	0	0	0	0	0	-2	-1	-1	0	0	0	0	0	0	-2
Y25	-2	0	0	-1	-48	-6	0	0	0	0	-3	-3	-10	-28	-10	0	-2	-5
Y26	-34	0	0	-28	-110	-14	-45	-155	-253	-38	-355	-184	-233	-343	-399	-2	-25	-939
Y27	-3	0	0	0	-1	0	-1	-6	-1	0	-6	0	-5	-7	-11	0	0	-22
L	-71	0	0	-21	-32	-4	-64	-40	-218	-44	-392	-352	-182	-540	-785	-15	-67	-1015
K	-420	0	0	-46	-107	-14	-305	-192	-283	-27	-384	-315	-268	-572	-594	-47	-80	-890
TAXL	-22	0	0	-6	-8	-1	-40	-10	-64	-12	-97	-112	-47	-159	-217	-4	-18	-288
SUBP	39	0	0	0	0	0	0	7	5	2	8	4	2	5	9	0	1	34
TAXP	-19	0	0	-1	-146	-19	-50	-3	-259	0	-7	-4	-4	-6	-10	-1	-1	-8
TAXC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TAXLS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tradebal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[7] Financial flow between Rest of Spain and Basque Country is only implicitly captured in the SAM.

Table A1: (Continued)

	Y19	Y20	Y21	Y22	Y23	Y24	Y25	Y26	Y27	PRIV	GOVT	I	Mros	Mrow	Xros	Xrow	Total
Y1	0	0	-3	0	0	0	0	-218	-23	-795	0	-12	975	354	-77	-49	0
Y2	0	0	0	0	0	0	0	0	0	0	0	0	36	18	0	0	0
Y3	0	0	0	0	0	0	0	0	0	0	0	0	0	1047	0	0	0
Y4	-1	-2	-139	0	0	0	0	-5	0	-1	0	0	154	76	-10	-10	0
Y5	-2	-12	0	0	-289	-14	-3	-11	-4	-572	0	-28	137	52	-245	-303	0
Y6	-1	-2	0	0	0	0	0	-7	-2	-270	0	0	178	184	-150	0	0
Y7	-17	-16	-4	-14	0	0	0	-112	-37	-224	0	0	363	0	0	0	0
Y8	-12	-11	-21	0	-5	0	0	-59	-46	-175	0	0	0	0	-83	0	0
Y9	0	0	0	0	0	0	0	-640	-65	-2165	0	-45	1842	407	-860	-253	0
Y10	-4	-10	-3	0	-1	0	0	-18	-14	-815	0	-3	716	191	-107	-96	0
Y11	-22	-156	-78	0	-23	0	0	-380	-115	-199	0	-23	389	322	-999	-315	0
Y12	-123	-29	-40	0	-21	0	0	-75	-16	-100	0	-25	125	137	-750	-739	0
Y13	-54	-61	-36	-1	-5	-1	-1	-95	-100	-320	0	-1	1275	472	-740	-310	0
Y14	-442	-581	-227	-1	-2	0	0	-15	-2	0	0	-26	2058	1366	-1059	-1737	0
Y15	-267	-86	-866	0	-3	0	0	-4	-2	-2	0	-438	515	178	-1258	-658	0
Y16	0	0	-185	0	-1	0	0	0	0	0	0	0	189	2	-9	-11	0
Y17	-21	-2	-76	0	0	0	0	-8	-2	-5	0	0	110	34	-144	-108	0
Y18	-142	-56	-465	-1	-6	0	0	-362	-23	-329	0	-2583	1998	1666	-2211	-2407	0
Y19	2841	-2	0	-9	-24	-12	-14	-85	0	-375	0	-703	733	541	-623	-2230	0
Y20	-136	2743	-194	-1	-2	0	0	-16	-22	-212	0	-544	349	421	-1189	-901	0
Y21	-6	-9	6337	-6	-51	0	0	-1796	-169	-12	0	-4159	0	0	0	0	0
Y22	-6	-5	-3	111	-5	0	0	-26	-11	-46	0	-2	55	0	0	0	0
Y23	-56	-79	-175	-5	2409	-17	-14	-419	-156	-727	0	-81	791	43	-540	-342	0
Y24	-2	0	0	0	-1	87	0	-61	-18	-85	0	0	142	7	-32	-30	0
Y25	-4	-5	-1	0	-4	0	94	-6	-3	-18	0	-1	135	12	-37	-44	0
Y26	-439	-356	-1497	-12	-487	-9	-13	16764	-959	-9463	0	-573	2334	38	-1841	-330	0
Y27	-44	-5	-16	0	-16	0	0	-72	6526	-2063	-4126	-187	76	1	-6	-5	0
L	-455	-586	-1082	-70	-457	-20	-21	-4033	-3564	14130	0	0	0	0	0	0	0
K	-409	-506	-832	-40	-850	-8	-22	-6965	-541	14717	0	0	0	0	0	0	0
TAXL	-128	-174	-310	-21	-156	-8	-6	-1173	-972	0	4053	0	0	0	0	0	0
SUBP	17	14	6	70	17	2	0	84	391	0	-717	0	0	0	0	0	0
TAXP	-65	-6	-90	0	-17	0	0	-187	-51	0	954	0	0	0	0	0	0
TAXC	0	0	0	0	0	0	0	0	0	-1926	1926	0	0	0	0	0	0
TAXLS	0	0	0	0	0	0	0	0	0	2090	-2090	0	0	0	0	0	0
Savings	0	0	0	0	0	0	0	0	0	-9434	0	9434	0	0	0	0	0
Tradeba	0	0	0	0	0	0	0	0	0	-604	0	0	-15675	-7569	12970	10878	0
Total	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Source: From Input-Output Tables 1999 Basque Country (EUSTAT, 2000)

Table A2: Sectoral Production, Consumption and CO2 Emissions calculated from SAM

			Production		Consumption		Emissions	
	Sector Numbers and Description	A-84 Code	mln Euro	(share)	mln Euro	(share)	Gg CO_2	(share)
Y1	Agriculture	1-4	676	(1,1%)	764	(3,6%)	539	(3,8%)
Y2	Coal Extraction	5	0	(0,0%)	0	(0,0%)	0	(0,0%)
Y3	Oil and Natural Gas Extraction	6	0	(0,0%)	0	(0,0%)	0	(0,0%)
Y4	Other Product Extraction	7-9	152	(0,3%)	1	(0,0%)	52	(0,4%)
Y5	Oil Refineries Products	23	1449	(2,4%)	270	(1,3%)	176	(1,2%)
Y6	Gas Natural Products	23	184	(0,3%)	240	(0,9%)	25	(0,2%)
Y7	Electricity	52	672	(1,1%)	182	(0,9%)	2995	(21,2%)
Y8	Energy Distribution	53. 54	570	(1,0%)	154	(0,7%)	52	(0,4%)
Y9	Food Industry	10-16	1846	(3,1%)	2009	(9,5%)	77	(0,5%)
Y10	Clothes. leader and shoes industry	17-19	186	(0,3%)	699	(3,3%)	30	(0,2%)
Y11	Paper and Cardboard Industry	20-22	1797	(3,0%)	172	(0,8%)	213	(1,5%)
Y12	Plastic Industry	27.28	1847	(3,1%)	84	(0,4%)	168	(1,2%)
Y13	Chemic Industry	24-26	1033	(1,7%)	270	(1,3%)	94	(0,7%)
Y14	Iron and Steel Industry	32-34	2396	(4,0%)	0	(0,0%)	663	(4,7%)
Y15	No metallic Industry	31.35-37	3445	(5,8%)	1	(0,0%)	140	(1,0%)
Y16	Cement Industry	30	87	(0,1%)	0	(0,0%)	161	(1,1%)
Y17	Glass Industry	29	280	(0,5%)	4	(0,0%)	143	(1,0%)
Y18	Machines Industry	39-45	5309	(8,9%)	263	(1,2%)	132	(0,9%)
Y19	Transport machines Industry	46-48	2841	(4,7%)	306	(1,4%)	47	(0,3%)
Y20	Rest of industry	38.49-51	2743	(4,6%)	169	(0,8%)	222	(1,6%)
Y21	Construction	55	6337	(10,6%)	11	(0,1%)	0	(0,0%)
Y22	Transport by train	60	111	(0,2%)	42	(0,2%)	0	(0,0%)
Y23	Transport by road	61.62.65	2409	(4,0%)	656	(3,1%)	5029	(35,6%)
Y24	Transport by air	64	87	(0,1%)	70	(0,3%)	244	(1,7%)
Y25	Transport by water	63	94	(0,2%)	16	(0,1%)	52	(0,4%)
Y26	Commercial services	56-59. 66-72. 74. 82.83	16764	(28,0%)	8655	(41,0%)	305	(2,2%)
Y27	Non Commercial services	73.75-81	6526	(10,9%)	6135	(29,0%)	102	(0,7%)
	Household						2590	(17,4%)
	Total		59841	(100%)	21173	(100%)	14250	(100%)

Table A3: Energy Balance For Basque Country 1999 (Ktep)

		Crude	Coal	Oil	Gas	Electricity
Y1	Agriculture	0	0	116	1	3
Y2	Coal Extraction	0	0	0	0	0
Y3	Oil and Natural Gas Extraction	0	0	0	0	0
Y4	Other Product Extraction	0	81	140	1	6
Y5	Oil Refineries Products	9693	0	0	0	0
Y6	Gas Natural Products	184	369	329	0	0
Y7	Electricity	0	0	279	1	40
Y8	Energy Distribution	0	0	12	21	21
Y9	Food Industry	0	9	20	323	372
Y10	Clothes industry	0	16	8	36	23
Y11	Paper and Cardboard Industry	0	0	12	3	3
Y12	Plastic Industry	0	148	6	16	19
Y13	Chemic Industry	0	0	0	85	13
Y14	Iron and Stell Industry	0	0	13	54	62
Y15	No metalic Industry	0	0	8	61	113
Y16	Cement Industry	0	0	7	11	22
Y17	Glass Industry	0	0	3	6	4
Y18	Machinery Industry	0	0	26	61	79
Y19	Transport machinery Industry	0	0	23	41	52
Y20	Rest of industry	0	0	45	14	21
Y21	Construction	0	0	1	0	6
Y22	Transport by train	0	0	0	0	18
Y23	Transport by road	0	0	1089	0	0
Y24	Transport by air	0	0	54	0	0
Y25	Transport by water	0	0	10	0	0
Y26	Comercial services	0	0	40	61	147
Y27	Non Comercial services	0	0	13	20	49
	Households	0	1	166	156	197

Source: (EVE, 2000)

Table A4: Physical emission coefficients and contribution of fossil fuels in combustion

	Coal	Oil	Gas
Ton CO_2 Equiv. / Ktep	4,104	2,851	2,187
Chemical Industry[2]	69%	65%	38%
Industry[2]	-	75%	-

Source: [1](Eurostat 1991), [2](Eurostat 2005)

Table A5: Price of Energy (M€/Ktep)

	Crude[1]	Coal[2]	Oil[1]	Gas[3]	Electricity[3]
Producers	0.108	0.105	0.265	0.219	0.763
Consumers	-	-	1.062	0.472	1.135

Source: [1] (IEA 1998) [2] (MITYC 2001) and [3](Eurostat 2005)

Table A6: Elasticities of Substitution on production, trade and consumption

Elasticities	Values	Elasticities	Values
$\sigma_j^{KEL\ (1)}$	0.5 (Sect. 1-3, 5-8)	σ^E	0.3
	0.69 (Sect. 4, 9-21)	σ^{E1}	0.5
	0.88 (Sect. 22-25)	σ^{E2}	2
$\sigma_j^{KL\ (2)}$	0.56 (Sect. 1)	σ^U	0.5
	1.12 (Sect. 2, 5, 7, 8)	σ^C	0.5
	1.26 (Sect. 3, 4, 6, 9-10, 26, 27)	σ^F	1
	1.40 (Sect. 21)	σ^G	1
	1.68 (Sect. (22-25)	$\sigma^A = \sigma^T$	3

Source: Gomez A., Faehn T., & Kverndokk S (2004) and (1) Kemfert & Welsch (2000); (2) Hertel (1997)

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(lxv) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications” organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 25-27, 2003

(lxvi) This paper has been presented at the 4th BioEcon Workshop on “Economic Analysis of Policies for Biodiversity Conservation” organised on behalf of the BIOECON Network by Fondazione Eni Enrico Mattei, Venice International University (VIU) and University College London (UCL) , Venice, August 28-29, 2003

(lxvii) This paper has been presented at the international conference on “Tourism and Sustainable Economic Development – Macro and Micro Economic Issues” jointly organised by CRENoS (Università di Cagliari e Sassari, Italy) and Fondazione Eni Enrico Mattei, and supported by the World Bank, Sardinia, September 19-20, 2003

(lxviii) This paper was presented at the ENGIME Workshop on “Governance and Policies in Multicultural Cities”, Rome, June 5-6, 2003

(lxix) This paper was presented at the Fourth EEP Plenary Workshop and EEP Conference “The Future of Climate Policy”, Cagliari, Italy, 27-28 March 2003

(lxx) This paper was presented at the 9th Coalition Theory Workshop on "Collective Decisions and Institutional Design" organised by the Universitat Autònoma de Barcelona and held in Barcelona, Spain, January 30-31, 2004

(lxxi) This paper was presented at the EuroConference on “Auctions and Market Design: Theory, Evidence and Applications”, organised by Fondazione Eni Enrico Mattei and Consip and sponsored by the EU, Rome, September 23-25, 2004

(lxxii) This paper was presented at the 10th Coalition Theory Network Workshop held in Paris, France on 28-29 January 2005 and organised by EUREQua.

(lxxiii) This paper was presented at the 2nd Workshop on "Inclusive Wealth and Accounting Prices" held in Trieste, Italy on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics

(lxxiv) This paper was presented at the ENGIME Workshop on “Trust and social capital in multicultural cities” Athens, January 19-20, 2004

(lxxv) This paper was presented at the ENGIME Workshop on “Diversity as a source of growth” Rome November 18-19, 2004

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(lxxvii) This paper was presented at the Workshop on Infectious Diseases: Ecological and Economic Approaches held in Trieste on 13-15 April 2005 and organised by the Ecological and Environmental Economics - EEE Programme, a joint three-year programme of ICTP - The Abdus Salam International Centre for Theoretical Physics, FEEM - Fondazione Eni Enrico Mattei, and The Beijer International Institute of Ecological Economics.

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