The proposals for a European tax on CO_2 and their implications for intercountry distribution

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Abstract

This paper analyzes the advantages and implications of the implementation of a European tax on carbon dioxide emissions as an own resource of the European Union. In contrast to a harmonized tax, which would only have distributive effects within each member state, a tax collected at European scale would also have important distributive effects among different countries. These effects would also depend on the use of tax revenues. The paper investigates the distributive effects among the member states of three tax models: a pure CO_2 model; a 50%/50% energy-CO_2 model and a CO_2 model with a burden on nuclear power.

Keywords: carbon tax, distributive effects, energy tax, European Union, inter-country distribution

JEL classification: D30, H30, Q25, Q48

1. The debate on the taxation of CO_2 emissions in the European Union

At the beginning of the nineties, in the context of preparing for the Rio Earth Summit, the European Union (EU) was considering the possibility of establishing a harmonized tax on fossil fuels burdening each of them differently — according to the carbon emissions associated with their use. A carbon tax increases the price of fossil fuel energy products and reduces their consumption. This leads to overall energy savings as well as investments in efficiency improvements and changes the consumption and production structures making them less energy intensive.

The debate in the European Union faced many vicissitudes. In June of 1992 the Commission presented a directive proposal (COM (92) 226 final; European Commission, 1992). According to this proposal, a national tax of mixed type would be established through which the different forms of energy would be taxed according to their energy content and to the CO_2 emissions emitted in their use. In general, renewable energies would be exempt. Although the hydroelectric energy generated in units with a power greater than 10 megawatts was burdened with a reduced rate. The tax was specifically designed so that in the case of petroleum, half of the tax burden would come from its energy content and the other half from its carbon content. The tax rates were fixed so that at the moment of their application, 1993, petroleum would support a tax equivalent to $3 per barrel that would increase until reaching a value of $10 per barrel in 2000, which would be achieved with a tax of about $22 per ton of CO_2 (O'Connor, 1997). Important exemptions were planned for the most energy-intensive industrial sectors. The application of these types of exemptions has been a general characteristic in the introduction of ecotaxes in Europe and it has just been denounced as a factor that reduces the environmental effectiveness of these taxes (Ekins and Speck, 1999). One of the most significant points was that the practical application of the directive was conditional to its main competitors of the OECD establishing similar tax measures.

In spite of the moderated and cautious nature of the proposal, the resolved opposition of some governments thwarted the initiative. It can be noted that when environmental policy decisions affect the tax system, the current regulation of the EU requires that they are accepted unanimously. Thus any decision about environmental taxation can be blocked — even by only one country of the EU.

In May of 1995 a new directive proposal was outlined (COM (95) 172 final; European Commission, 1995). Although the content of the proposal was very similar, an important modification was introduced. The directive fixed the harmonized structure of the tax, but the member states could, during a transitional period, fix the tax rates freely. The rates planned for the year 2000 -equivalent to a tax of $10 per barrel in the case of petroleum- were not obligatory, but a "target rate" on which member states would try to converge. In spite of these changes, the directive failed again because of government opposition of some countries. Even more moderate and partial proposals such as the one of March 1997 (COM (97) final; European Commission, 1997), consisting of increasing the harmonized minimum rates in several phases on some energy products, have still been blocked — mostly due to the opposition of the Spanish government.

It should be pointed out that the proposals, both the one of 1992 and the one of 1995, consisted of the harmonization of minimum taxation levels, but not a tax collected at the level of the European Union as an own resource. This last possibility has been practically nonexistent in the debate. However, in a European Commission report (1993) about EU revenue sources, one section is devoted to possible new own resources and the possibility of a CO_2 tax is considered. It appears, among other alternatives, as the one that fulfils more favorable criteria (Table 31, p. 85); according to this report "there exists also a clear economic case for assigning the ensuing revenue to the supranational level of government." (p. 91)

While application of the tax at the European level is blocked, some countries have decided to apply carbon taxes (Denmark, Holland, Norway, Sweden, Ireland, and Italy), while others (Austria and Germany) have opted for increasing energy taxes. In addition to these taxes, there are other taxes that also affect energy products and the implicit tax on carbon varies a lot among the different energy products and the different EU countries (Baranzini, *et al*., 2000). This creates serious problems when trying to implement international coordinated taxes.

2. Harmonized national taxes or international tax?

The theoretical economic argument for a unique tax on a global problem is that it faces the problem in a more efficient way. With a unique tax the marginal “costs” of reducing emissions tend to equalize, thus achieving a joint reduction of emissions at a smaller total “cost”.[1] Several empirical studies show that a unique economic instrument for different countries leads to a reduction at a smaller cost than applying the instrument individually. Among them, Conrad and Schmidt (1998) and Barker (1999) estimate that the necessary tax rate to reduce Community emissions to a certain level is lower in the case of a coordinated tax than in the case of non-coordinated taxes.

However, these arguments do not allow for deciding between the two alternatives of introducing unique tax rates: national harmonized taxes or international tax. A unique world-wide tax is quite unthinkable for the moment and the proposal is not on the agenda. But it is perfectly conceivable that an entity like the EU, which has a Community budget with revenues and expenditures, can decide to introduce a supranational tax of this type as an own resource. Nevertheless, the specific proposals that have been suggested consist of harmonized taxes that would become part of the revenues of each country.

Some advantages of a tax levied and collected at the EU level are listed below.

a) Greater incentives for environmental policies. The strategies for reducing greenhouse emissions are established, to a great extent, at a national level. As the problem is a global one, the typical free-rider problems appear, not only at the level of individual economic agents, but also at the governmental level. With an international tax, any unit reduction would imply a reduction in the net contribution of each country to the budget of the European Union. This could reduce the aforementioned problems. With a harmonized tax, a country would not be interested in making the effort that reducing emissions implies and could reduce other taxes or tax substitutive goods (renewable energies) and so its productive and consumption structure would remain unchanged (Hoel, 1992). Consequently, it is foreseeable that, in order to achieve the same level of global reduction, the harmonized tax rate required would be higher than the international tax and would yield more inefficiencies.[2]

b) An international tax avoids the possible perverse effect that could imply turning environmental taxation into an important part of the public revenues of a country. Since the success of the policies for reducing environmental impacts would reduce the tax base and thus the fiscal revenues, it could be possible that the governments will not be interested in the success of this tax in order to avoid the "fiscal erosion". This problem disappears with an international tax (although, concerning environmental policies, it could move to the supranational level).

c) An international tax generates an own source of budget revenues, which can be considered positive if one thinks that the economic union should be accompanied by a bigger budgetary expenditure.[3] The objective of the taxes analyzed here is not that of obtaining revenues. However, a carbon tax is a clear example of an environmental tax that would generate important revenues for the public sector, even though it has to be noted that, with other things remaining unchanged, the more effective the tax is from the environmental point of view the lower the revenues will be. In the simulations shown later, in the specific case of the EU, a tax levied on CO_2 could mean -at least in the short term- significantly bigger revenues than the current level of EU budgetary expenditures.

d) A more controversial question is that of the advantages or disadvantages of a harmonized or supranational tax from the point of view of the distribution among countries. It is possible that an international tax could have regressive effects. However, the revenues would return in one way or another to the citizens of the EU, so that what is a possible disadvantage from the distributive point of view could become an advantage either by public expenditure or direct transfers, the effects could be highly positive, while a harmonized tax would not have redistributive effects among countries.[4] Next, we review some studies on the distributional effects of environmental taxes -and in particular of CO_2 taxes- generally inside a country. However, let us remember that the "progressive" redistributive effects can be a desirable characteristic of ecotaxes (and therefore they can guide us in their design), but the redistribution is not its main objective: in fact we do not want "horizontal equity" here because it is desirable that two countries with the same per capita income should contribute more or less according to its effort in reducing emissions.

3. Environmental taxes and their distributive impact: a general view

The issue of the distributional effects of environmental taxes has three aspects: how fiscal burden is distributed, what distributive effects the use of the revenues has (the bigger expenditure and/or the reduction of other revenues) and who benefits by the positive environmental effects.

The most complex aspect to study is generally the last one, that of the distribution of the environmental benefits (or avoided costs).[5] In addition, in global problems such as climate change, there is a great uncertainty about the avoided costs and these do not only affect the inhabitants of a certain country but also -and mainly- to future generations and the inhabitants of other places in the world.[6]

Empirical research has generally focused on the first subject, that of the allocation of the fiscal burden, and it has usually been discussed regarding the effects that a "national" tax (though maybe harmonized for different countries) would have inside a country for the different social groups, classified according to their income or expenditure levels. Actually, most studies refer to taxes on non-renewable energy and/or on carbon emissions.

The initial aforementioned studies only took into account the direct effects based on the energy purchases by the different families (data that are usually obtained from surveys of family expenditure) but not the direct and indirect effects of a rise in the price of energy that would affect all economic sectors. In general, it was shown that as well as the percentage of the total expenditure devoted to energy consumption for domestic use tended to decrease with the level of income or expenditure, on the other hand the expenditure in motor fuel performed the opposite. According to Poterba (1991) a carbon tax would be regressive for the United States, though the regressivity was much lower if the reference variable was household expenditure rather than household income. In the case of the United Kingdom, the studies concluded that the effects of a tax on non-renewable energies would be regressive because the groups of lower income would confront a greater increase in prices than the groups of higher income (Smith, 1992). However, the results could not be generalized for all the European countries. Following the comparative study of Smith, the regressive effects would be significant in Ireland and the United Kingdom while in other countries, like Italy and Spain, a tax of this kind would probably have proportional effects for the different income levels, a result confirmed in later studies (e.g. Pearson, 1995).

However, the distributive effects of a CO_2 tax (and in general of any energy tax) should also take into account how the different goods and services are affected in their prices. For this object, the information derived from input-output relationships of the different sectors has to be used. These relationships should have a sufficiently high disaggregation level and should be compatible with the expenditure classification of the family budgetary surveys. These studies are more complex and less abundant, among them we can mention the one of Biesiot and Noorman (1999) for the Netherlands, which concluded that the mean elasticity of the total use of energy with relation to the income level was 0.8, although families with similar income levels but different lifestyles had very different levels of energy requirements. An elasticity less than the unit would lead us to foresee that, in principle, the effects of a tax would very likely be regressive.

Other studies also introduce assumptions about the changes that a tax could operate in the demand function of the different goods (altering the structure of consumption) for the different groups of families according to their income or expenditure level. These studies are very interesting but in general are very limited because of their very high aggregation level. Among them we can cite the one of Symons, Proops and Gay (1994) for the United Kingdom, the one of Cornwell and Creedy (1996) for Australia and the one of Labandeira and Labeaga (1999) for Spain. In the first two cases the regressive character of the carbon tax seems to be confirmed for the studied country, while the recent work on the Spanish case concludes that the direct and indirect total impact of the tax would affect, more or less proportionally, the consumption of the different expenditure groups.

The reviews of Bruce et al. (1996) for the OECD, Barker and Köhler (1998) for the UE, the ones of the OECD (1995 and 1997), as well as the one of Speck (1999) show that the distributive implications of energy and carbon taxes would be in general slightly regressive. But, as most of the mentioned works outline, the ultimate effect on the income distribution is not independent of how the generated revenues are used. The first possibility is to finance environmental projects in order to improve the effectiveness of the policies. Another possibility is to reduce other public revenues, an alternative that is usually associated with the term "environmental fiscal reform";[7] in such cases the effects would depend on the degree of progressivity/regressivity of the reduced revenues in relation to the new tax.

Finally, the other alternative is to distribute these revenues, or part of them, through additional public expenditure or transfers. A case frequently considered in the literature is lump-sum redistribution, that is to say, making equal monetary transfers to everybody, in which case the effects tend to be highly progressive. It is worthwhile to notice that this redistribution would be equal in its effects on the income distribution to increase public expenditure that equally benefits all families independent of their income level. If the per capita benefit of the public expenditure correlates negatively with the income level, then the effects would be even more progressive from the redistributive point of view.

There are some examples in which the revenues from the environmental taxes are actually returned -in a more or less direct way- to the citizens. In Switzerland the revenues from different environmental taxes (domestic fuel, sulphur, and COV) are returned through a per capita reduction in the medical insurance. The Netherlands' design of the small energy user's tax, applied with a tax-free allowance, reduces the income tax and social taxes, which also compensate any regressive effect (EC, 1999, cited in Ekins and Barker, 2001).

The approach taken in most of the studies about environmental taxation and income distribution has focused on the effects inside a country on the different social groups. An exception is the work of Whalley and Wigle (1991) that elaborates a general equilibrium model to discuss the effects of an international carbon tax in 6 different regions of the world (European Union, North America, Japan, Other OECD, Oil Exporters, Developing/Centrally planned). The costs of the tax under three possible designs are valued: harmonized tax on national production, harmonized tax levied on national consumption, and international taxes collected at world level by some international organization and whose revenues are distributed on a per capita egalitarian basis. As could be expected, the effects are very different under the three designs. Under the two first cases the poorest countries are affected very negatively by the tax, though the distribution of the costs among countries depends on the nature of the tax: a national tax on production would benefit oil exporters while those countries would be very negatively affected in the case of taxes on consumption. In the last case –international tax with redistribution– poor countries are clearly favored thanks to the enormous transfers, basically from North to South (Whalley and Wigle, 1991, Table 7.6, p. 250 and Table 7.7., p. 255).

In conclusion, a carbon tax does not necessarily have regressive impacts among countries or inside the countries - which would be an undesirable characteristic - but rather this depends on its design and on the use that is made of the revenues it generates.

4. The distributive effects: the EU case

4.1. Objective and assumptions

This section studies the possible effects of the introduction of a carbon tax collected at a Community level on the income distribution among the different countries of the European Union.

The only reference in the literature about this that we know comes from a report (European Commission, 1993), already cited, about the possible new sources of revenues of the EU. This report estimates the fiscal revenues that a tax of this type would collect in any member state, expressed as a percentage of their GDP, and assumes that the tax is equivalent to $10 per barrel of oil. This is the level that the directive proposal of 1992 planned for the year 2000. The report does not specify the methodology of computation (for example, whether the structure of the tax is assumed to be exactly equal to the directive proposal or not, or whether it includes exemptions for some industries or not) and uses the 1989 GDP and emissions data. The potential revenues are estimated –in the "static assumption" that the emissions would not change- as 1.14% of the EU GDP, with figures between 2.45% for Greece and 0.79% for France. The general conclusion is that "the carbon dioxide levy looks slightly regressive, although the picture is by no means simple as the CO_2 intensity of an economy is the outcome of a multitude of factors" (p. 91).

Our paper analyzes the same issue in a much more detailed way, with up-to-date data and simulating different alternative models of carbon tax. In short, we have considered a pure model of imposition on CO_2; a mixed model 50%/50% energy-CO_2 and a pure model on CO_2 but also strongly taxing nuclear energy.

The first measure, a pure model of CO_2 tax, simply consists of imposing the same tax rate per ton of CO_2 emitted by each energy source. Therefore, it implies imposing a tax only to fossil energies and with different rates per unit of energy. In short, we have considered a positive rate of 50 euros (equivalent to almost $45 at the current exchange rate) per ton of CO_2,[8] this imposes a much higher taxation for fossil energies than the one included in the European directives proposal that we analyzed in Section 1. What is of fundamental interest to us is the regressive or progressive character of each modality of the tax application which does not depend on the tax rate, although, of course, the redistributive capacity of the tax crucially depends on the tax rate.

The mixed tax considered is designed so that it yields the same revenues as the pure CO_2 tax of 50 euros per ton of CO_2 (assuming that the consumption of the different types of energy remains unchanged). Therefore it is very similar to the European directive proposals for 1992 and 1995. The difference is not only in the tax rates but also exemptions for specific industries are not considered. These proposals introduced a mixed tax that, in the case of petroleum, lead to a fiscal burden that is 50% due to its energy content and 50% to its CO_2 emissions. In this article, instead, our calculations take into account the energy structure of the EU in 1999, therefore 50% of the fiscal revenues come from CO_2 emissions and the other 50% from the (non-renewable) energy content. In comparison with the previous model, this implies not only imposing a burden on nuclear energy, but also to change the structure of the tax to reduce the differences between the tax burden imposed on coal, petroleum, and natural gas. Given the constraint of fiscal revenues equal to the ones of the pure CO_2 tax, this is equivalent to a tax of 25 euros per ton of CO_2 plus 58.44 euros per ton of equivalent petroleum (for fossil energies and nuclear energy; we consider all renewable energies exempt, including all energy generated by hydroelectric power stations).

In the third tax model, the fiscal burden on nuclear electricity has been increased, establishing it in a way that it at least carries a burden equivalent to the one that would correspond to the production of the same electricity through the energy source with a higher burden, i.e. coal. We used the estimations of the International Energy Agency (2000, Table 2, p. 93); the last available estimation of emissions for obtaining electricity from coal corresponds to 1998 and they are very different for the different countries. In the case of the European Union they vary between the 541 gr. of CO_2/kw-h for Denmark and the 1045 for France and Italy. We have taken this last figure (which is equivalent to 4.31 tons of CO_2 per TEP of nuclear energy), so the substitution of nuclear energy for the energy coming from thermal power stations does not yield a fiscal saving.

The emissions from international aviation and navigation are not considered in any of the models. Not because we believe that they do not have to be taxed. We agree with Scher (2000) in that the current situation of fiscal exemption for these fuels in the European Union and in many other countries is scandalous and in fact represents an unacceptable subsidy to the long distance displacements (of tourists, goods, etc.). However, the effects of the tax on these emissions in the different countries would be particularly difficult to distribute.

4.2. The distribution of the fiscal burden among different countries

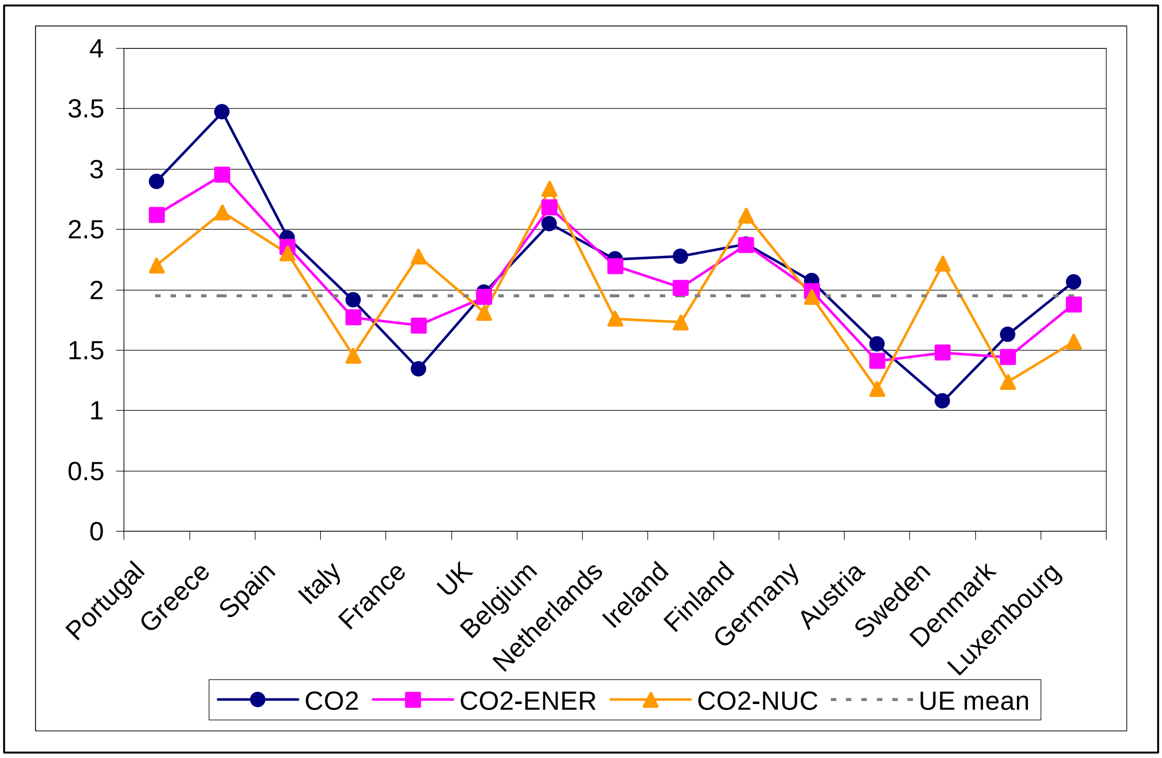
Here we analyze the distributive impacts among the different countries of the different tax alternatives. The "static" assumption is that the CO_2 emissions and the energy structures of the countries remain unchanged; however, the qualitative results would also be representative of a situation in which the emissions and consumption of all the countries vary more or less in the same proportion. We are implicitly considering that the "cost" is borne by the citizens of the country collecting the revenues. This can be considered a first approach; although obviously the reality is that the taxes affect prices which in turn affect the consumers of different goods and services located in other countries. This is particularly important in very interrelated economies, however, taking this fact into account would require using much more complex models. Every country (independent of its demographic weight) is treated as an observation, because we are not concerned with what happens internally, but in the distribution among countries.

Table I and Figure 1 show the increase in fiscal burden (as percentage of GDP) that any of the considered taxes would represent for the different member states, listed according to their per capita GDP. The relationship between per capita GDP and the tax burden is not very significant, however, the figure shows mildly regressive impacts that are smaller in the third tax design.

Table I. Added fiscal burden (% of GDP) that would represent different tax options according to the assumptions detailed in the text

		Tax revenue as a percentage of GDP		
	per capita GDP	CO_2	CO_2-Energy	CO_2-Nuclear
Portugal	10579	2.89	2.62	2.20
Greece	11149	3.47	2.95	2.64
Spain	14190	2.43	2.35	2.30
Italy	19072	1.91	1.77	1.46
France	22307	1.34	1.70	2.28
UK	22735	1.98	1.94	1.81
Belgium	22814	2.55	2.68	2.84
Netherlands	23373	2.25	2.20	1.76
Ireland	23381	2.28	2.02	1.73
Finland	23540	2.38	2.37	2.62
Germany	24149	2.07	1.99	1.94
Austria	24153	1.55	1.41	1.18
Sweden	25272	1.08	1.48	2.22
Denmark	30736	1.63	1.44	1.24
Luxembourg	41230	2.06	1.88	1.57
EU	21147	1.95	1.95	1.95

Figure 1. Added tax burden of the different tax options



The first case depicts a pure CO_2 tax and shows that the share of GDP that represents the tax varies significantly among countries. This is logical since the fiscal burden depends on the "intensity of carbon dioxide emission" which is different in the different countries and depends on two factors: carbonization index and energy intensity:

$$CO_2/GDP = (CO_2/E)*(E/GDP)$$

where E represents the use of primary energy.

There is a certain controversy about the relative weight of both factors in explaining the differences of the emission intensity among countries (e.g. Ang, 1999; and Roca and Alcántara, 2000). In our case, we see that the deviation from the mean is similar in both cases, so that they would have a similar weight in the explanation of the differences (Table II). The differences in the first factor can be easily explained because they only depend on the structure of energy primary sources. We can highlight the very small figures of Sweden and France, which are explained fundamentally by the high weight of the nuclear energy inside their energy supply; at the opposite end, Greece and Ireland have high figures. In the case of Greece it is due to the important weight of coal and crude, while in Ireland it is because of the weight of petroleum products. The differences in energy intensity are more difficult to explain because they depend on a multitude of factors: productive structures, models of transport, energy efficiency, etc..

Table II. Intensity in carbon dioxide emissions

Index numbers	**Carbon intensity**	**Carbonization**	**Energy Intensity**
Portugal	148.6	120.2	123.7
Greece	178.2	142.7	124.9
Spain	124.8	106.6	117.2
Italy	98.2	115.2	85.3
France	69.0	65.7	105.1
UK	101.6	108.5	93.7
Belgium	130.7	94.3	138.6
Netherlands	115.7	107.0	108.1
Ireland	116.9	134.6	86.8
Finland	122.0	79.5	153.4
Germany	106.4	112.9	94.2
Austria	79.5	98.4	80.8
Sweden	55.3	43.3	127.8
Denmark	83.7	125.4	66.7
Luxembourg	106.0	107.9	98.2
EU	100.0	100.0	100.0
Standard deviation	*30.05*	*24.88*	*22.94*

In summary, the relative fiscal burden of the CO_2 tax depends directly on the relative carbon intensity. In this case, it causes a mildly regressive effect mostly because of the bigger fiscal burden on the part of the three countries with smaller per capita GDP of the Union. Two countries especially well treated by this first option are France and Sweden. In the other two tax designs, the three countries with smaller per capita GDP also have a bigger increase in the fiscal burden than the mean of the EU but the difference is less pronounced.

In general, if we compare the CO_2-energy design with the first model, the significant change is that now the nuclear energy is also taxed and there is an additional change as well: the countries with higher use of coal would be favored, while the users of natural gas would not be as favored as in the first model.[9]

Lastly, the CO_2-nuclear tax, as we have defined it, differentiates from the CO_2 tax structure only in that now the energy generated by nuclear power stations is taxed in a significant way. The result is that France and Sweden, the countries most favored by the first tax, now have an increase in the fiscal burden bigger than the mean of the EU.

In order to quantitatively analyze the progressive or regressive character of the different tax models considered, we will first estimate the Kakwani index for each case. We are only interested in measuring the effects on the per capita income distribution among countries, so we will treat the population of each country as if the internal distribution were completely egalitarian (as use to be assumed in inequality analyses at regional level). This index indicates whether the distribution of what is paid for the tax (shown by the concentration curve of the tax, ordering the countries not according to the tax variable but to the per capita income variable) is more or less unequal than the income distribution (shown by the Lorenz curve). If the distribution of the tax is more concentrated in the richer sections, then the tax is progressive. The index is computed as the difference between the "pseudo-Gini" or concentration index of the tax, minus the Gini index before the tax. The values can oscillate between –2 and 1. The positive values indicate progressivity and the negative regressivity. Given the mentioned assumption of equality in the income distribution inside each country, very low figures can be expected for the index, but what interest us is its sign and the comparison among the values in the different tax designs. In contrast with the former analysis in which each country was an observation that was equally represented in the table and the figure of added fiscal burden, now the inequality indicator would be more affected by what happens in a country with a larger population (to give an example, the fiscal burden on Luxembourg will have very little incidence on the global indicator) which can be considered a desired characteristic. Table III shows the results.

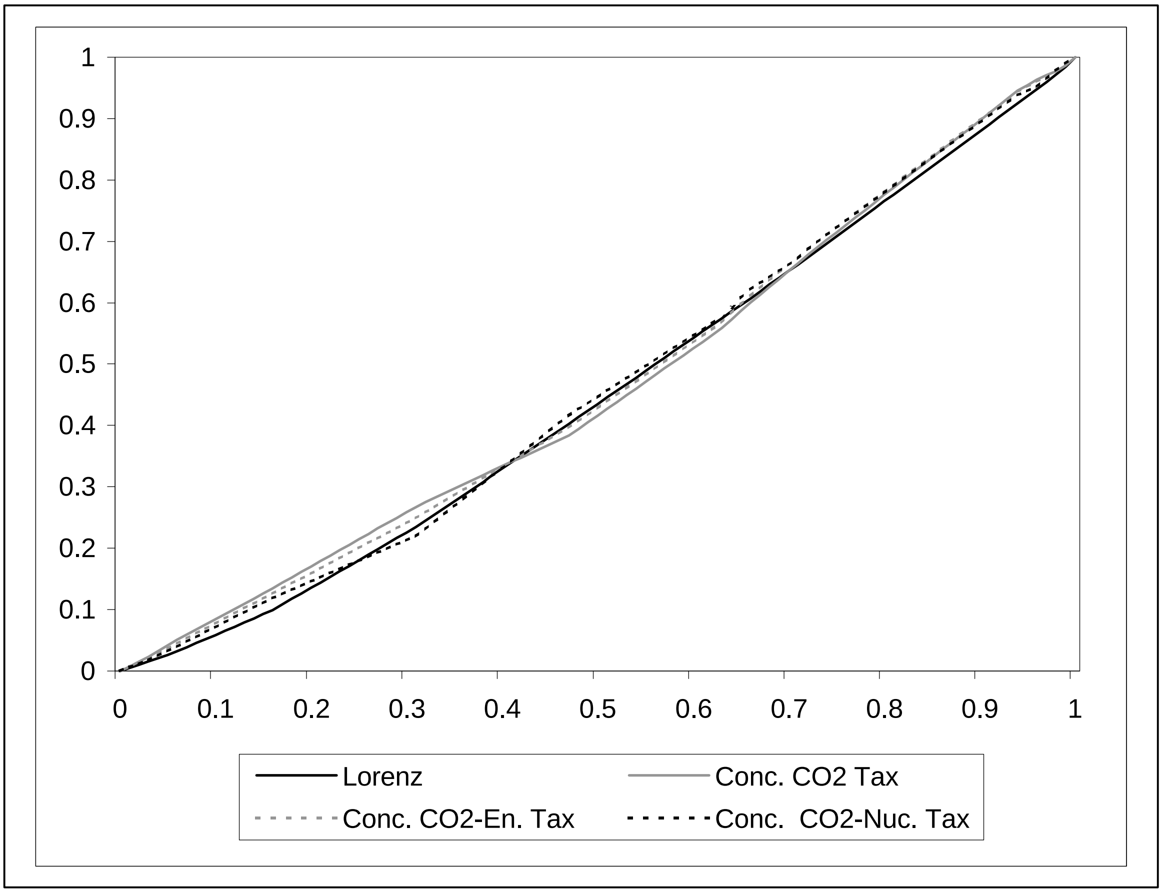
Table III. Kakwani index for the different tax designs

	Kakwani index
CO_2 Tax	-0.01933
CO_2-Energy Tax	-0.01913
CO_2-Nuclear Tax	-0.01462

The negative signs of the results confirm that the considered taxes can be regressive. It can be noted that the last tax design, which is the one that most penalizes nuclear energy, and in our opinion much more appropriate from an environmental point of view, is also the one that would have a less regressive incidence.

The Kakwani index is obtained from the global behavior of the concentration curves of the tax in comparison to the Lorenz curve of income distribution. The graphic analysis (Figure 2) allows us to observe that, especially in the first case, the regressivity of the tax is explained to a great extent by the burden that is borne by the share of population that is located in the poorer EU countries. This would be considerably attenuated in the third tax, which has a distribution of the fiscal burden more similar to the income distribution of the Community.

Figure 2. Lorenz curve and fiscal concentration curves of the different taxes



Another very clarifying way of observing the distributive incidence of a tax is through the comparison between the Gini inequality index before and after the application of the tax. The difference between these two indexes is the (reformulated) Reynolds-Smolensky index,[10] which measures the redistributive capacity of the tax and whose values are bounded between 1 and -1. The positive values indicate a decrease in inequality (*progressivity*) while the negative values indicate an increase in inequality (*regressivity*). The value of the index depends not only on the structure of the tax but also on the mean tax burden. For example, a tax on CO_2 of 50 euros will have more redistributive capacity than another designed in an identical way but with a rate of 30 euros, however the character of the redistribution, regressive or progressive, will be the same. The results are:

Table IV. Redistributive capacity of the different tax designs

	Gini index	Reynolds-Smolensky index
Initial situation	0.09751	
After CO_2 tax	0.09792	-0.00041
After CO_2-Energy tax	0.09793	-0.00042
After CO_2-Nuclear tax	0.09787	-0.00036

The signs show that the three taxes have a negative redistributive capacity. This negative redistribution is lower in the model that most penalizes nuclear energy while in the other two cases it is practically identical.

4.3. The distributive effects with return of the revenues through lump-sum transfers.

Next we analyze the distributive effects of these different tax alternatives assuming that the revenues obtained with the tax are transferred to the countries through lump-sum transfers according to the population of any member state. This assumption implies that it is more than a tax, it consists in what is known as a bonus-penalization system: no fiscal revenues are generated, some countries pay money while others receive it, and the sign of the transfer depends on the emissions being higher or lower than the EU mean. Although there are not fiscal revenues, polluting has a price equal to the tax rate fixed, given that for any unit of pollution money is paid or not received (opportunity cost).

Notice that, the lump-sum redistribution could be considered equivalent in its redistributive effects *among countries* to a hypothetical additional public expenditure benefiting in an exactly equal way to all the citizens of the European Union.

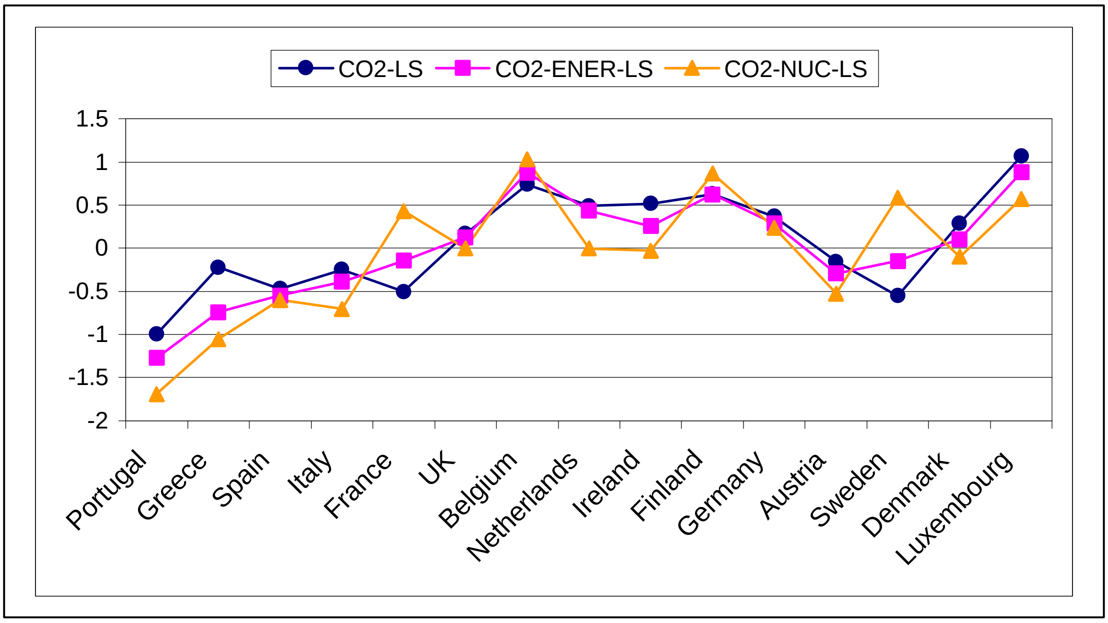
In the next table we can observe the effort in terms of (positive or negative) added fiscal burden (as % of GDP) that would represent the considered taxes.

Table V. Fiscal burden (as % of GDP) that represents each tax after lump-sum transfers

		Net tax as a percentage of GDP		
	Per capita income	**CO_2**	**CO_2-Energy**	**CO_2-Nuclear**
Portugal	10579	-1.00	-1.27	-1.69
Greece	11149	-0.22	-0.74	-1.05
Spain	14190	-0.47	-0.55	-0.60
Italy	19072	-0.25	-0.39	-0.70
France	22307	-0.50	-0.14	0.43
UK	22735	0.17	0.13	0.00
Belgium	22814	0.74	0.86	1.03
Netherlands	23373	0.49	0.44	0.00
Ireland	23381	0.51	0.26	-0.03
Finland	23540	0.63	0.62	0.87
Germany	24149	0.37	0.29	0.24
Austria	24153	-0.16	-0.29	-0.53
Sweden	25272	-0.55	-0.15	0.59
Denmark	30736	0.29	0.10	-0.10
Luxembourg	41230	1.07	0.88	0.57
EU	21147	0	0	0

The effect of the alternative taxes considered is now clearly different. In any of the alternatives, the four countries with a per capita income lower than the European mean receive a positive net transfer, and this is quite larger in the case of the later tax model, which is the one that most penalizes energy generated by nuclear power stations. Therefore, from the distribution point of view, lump-sum transfers would more than correct the moderate regressive impact of the tax. Although, of course, the tax could have redistributive effects among different population sectors inside each country, which depends crucially on the use of transferred revenues. This is reflected in the following figure, where it can be observed that the burden that the tax net of transfers implies would have a positive correlation with the per capita income of the different countries.

Figure 3. Fiscal burden added of the tax net of lump-sum transfers



As for the indicator of the redistributive capacity of the combination energy tax-lump-sum transfers, the following results have been obtained:

Table VI. Redistributive capacity of the net tax

	Gini index	Reynolds-Smolensky index
Initial situation	0.09751	
CO_2 tax	0.09601	0.00150
CO_2-Energy tax	0.09602	0.00149
CO_2-Nuclear tax	0.09597	0.00155

In each of the three cases, the very weak redistributive capacity of the tax net of transfers is positive, that is to say, any of the studied measures would lead to a more equitable income distribution. As would be expected from the previous analysis, the measure with more redistributive capacity would be the one that most penalizes nuclear energy.

5. Conclusions

In the present paper we have analyzed what would be the redistributive impacts among the different countries of the European Union with the introduction of a tax on carbon emissions collected at a community level. First, we have examined the proposals made by the European Commission that basically consisted of a mixed tax CO2/Energy. The paper has highlighted some advantages of a unique tax collected at a EU-wide level with respect to harmonized taxes collected by the different countries. We have also seen that both in the theoretical and empirical literature it is generally stated that energy taxation can be mildly regressive. Nevertheless, this depends both on the tax design as well as on how the revenues are used, which can attenuate the regressivity of the tax.

We have analyzed the effects of the tax on the different EU countries under three designs of energy taxation: a pure tax on CO_2, a mixed CO_2/energy tax, and a CO_2 tax with a strong burden on nuclear energy. Using the 1999 data we conclude that the application of the three taxes would be slightly regressive, although the degree of regressivity is smaller with the last design. The burden to be borne by the different countries depends in each case on their energy intensity, as well as on the weight of the different energy sources. Finally, we have shown that the regressive effect of the tax would be more than compensated if the revenues were returned to the countries according to its population.

We can conclude, thus, that energy taxation at the EU level cannot be refused on equity grounds and it could even be defended for the potential progressive effects the use of collected revenues could have. Moreover, we conclude that the tax alternative in which nuclear power is penalized is also the most interesting one in equity terms.

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Notes

1. "Cost" here means the sacrifice, measured in monetary terms, that the reduction of emissions is assumed to imply.
2. However, in the case of the international tax an important incentive would exist to "hide" emissions (Hoel, 1992). Although in the specific case of CO_2 emissions, whose value is directly related to energy consumption, these possibilities would surely be quite limited for the developed countries. Anyway, it is a difficulty that has to be overcome for any international policy that imposes obligations and potential penalizations to different countries.
3. But if the tax is introduced, as proposed in 1992 and 1995, in a context of "revenue neutrality", that is to say, without increasing the global fiscal burden, then there will not be additional revenues.
4. Although, of course, we can be concerned about whether it will affect macroeconomics more negatively to the richest or to the poorest countries (see European Commission, 1993). Jansen and Klaasen (2000) analyze the effects of applying the last directive proposal of 1997 consisting in minimum harmonized taxes, and conclude that it could bear a small increase of the GDP and a decrease of the emissions for most countries whenever the revenues are used to reduce social security contributions.
5. In the CO_2-energy tax, the positive effect derives from the reduction in the greenhouse emissions and its associated problems.
6. In spite of the extreme uncertainty regarding the avoided costs (or "benefits") some analyses like the one of Boyd et al. (1995) try to quantify them, and they conclude that the energy has a too low price, given the environmental damages it causes, and that a carbon tax would bear "net benefits".
7. The literature mentions the "double dividend" that these reforms could yield: on the one hand an environmental benefit and on the other hand an increase in employment if the reduction affects distortionary taxation of this factor (Pearce, 1991; Barker, 1995; Ekins, 1997; and Pezzey and Park, 1998).

8. Notice that emissions can be expressed in CO_2 tons or carbon tons. The emission of 1 ton of carbon is equal to 3.67 tons of CO_2, so the considered tax is equal to 183.5 Euros per ton of carbon (or near $165).
9. An argument for justifying this would be that in the extraction of natural gas important quantities of methane, one of the main greenhouse gases, are emitted.
10. The original formulation of the Reynolds-Smolensky (1977) index consisted in the difference between the initial Gini inequality index and the concentration index for the income after the application of the tax. However, it did not measure properly the redistributive effect in case of reranking of income units (Lambert, 1993).

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