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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 EU and it focuses on its effects on intercountry distribution. 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 through a simple empirical analysis 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.

Key words: 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.

The debate in the EU 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 harmonized 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. 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. These types of exemptions have been a general characteristic in the introduction of energy ecotaxes in Europe and it has been wisely denounced as a factor that reduces their environmental effectiveness (Ekins and Speck 1999). 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.

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 the opposition of some governments. 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, was blocked until recently.

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 EU 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. 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 EU. This could reduce the aforementioned problems. With a harmonized tax, a country could 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 be less affected (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.[1]

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 it could move to the environmental policies decided at 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. A carbon tax 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.

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 income distribution among countries. It is possible that an international tax could have some 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 because the effects of additional public expenditure or *direct* transfers could be highly positive, while a harmonized tax would not have direct redistributive effects among countries. Next, we review some studies on the distributional effects of environmental taxes —and in particular of CO_2 taxes. 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 exact "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). 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.[2]

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. 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 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 also 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 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. An elasticity less than the unit would lead us to foresee that, in principle, the effects of a tax would 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 even though in general are characterized by a very high aggregation level. Among them we can cite the one of Symons et al. (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 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 probably be slightly regressive in most cases. 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”;[3] in such cases the effects would mostly 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. We will also consider this distribution. However if the purpose was redistributing income this is not the most effective way, and if the purpose was giving priority to a macroeconomic objective –such as increasing employment– many authors suggest that the reduction of labor taxes is the best alternative. The advantage of per capita redistribution is that it seems more "equitable" among countries. It is worthwhile to notice that this redistribution would be equal in its effects on the income distribution to a hypothetical increase in 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 its effects would be even more progressive.

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 volatile organic compounds) are returned through a per capita reduction in the medical insurance. Other example is the Netherlands' design of the small energy user's tax; it combines a tax-free allowance with personal income tax and social contributions reductions, which is also oriented to 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 (EU, North America, Japan, Other OECD, Oil Exporters, Developing/Centrally planned). The costs of the tax for the different regions 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. 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 we would consider a very undesirable characteristic– but rather this depends on its design and on the use that is made of the revenues it generates.

4. The intercountry distributive effects: the EU case

4.1. Objective and assumptions

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

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 assuming 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).

We analyze the same issue in a greater detail, with up-to-date data and simulating three alternative models of carbon tax. In short, we have considered a pure model of tax on CO_2; a mixed model 50%/50% energy-CO_2 and a pure model taxing CO_2 but also taxing nuclear energy. Our purpose is to compare the effects of the different tax designs, assuming that each of them yields the same revenues and that no industries are exempted.

4.2. Methodology and data

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 tax of 50 euros per ton of CO_2,[4] 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 only depends on their structure but it does not depend on the specific tax rate, although, of course, the redistributive capacity of the tax would crucially depend on the tax rate.

Under this design, tax revenues from each country (T_i) are computed by multiplying the country's CO_2 emissions (CO_{2i}) by the tax rate (t):

$T_i = tCO_{2i}$

so $T = \sum_i T_i$ is the total revenue generated by the tax.

For this and the following calculations we used the data from the IEA (2001), which only includes fossil fuel emissions, which is the most appropriate database for the tax under consideration.

It might be highlighted that the revenues generated by the tax could mean –at least in the short term- bigger revenues than the current level of EU budgetary expenditures.

The mixed tax applies to both fossil energies and nuclear energy. It is designed so as to yield the same revenue 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). The design is very similar to the European directive proposals for 1992 and 1995 even though there are some differences. Firstly, the level of tax rates and exemptions for specific industries are not considered. Moreover, 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. Here we consider that 50% of the fiscal revenues would come from CO_2 emissions and the other 50% from the (non-renewable) energy content according to the energy structure of the EU in 1999.

Under this second model, the tax revenue from each country (T_i) is computed by multiplying the country's CO_2 emissions (CO_{2i}) by the tax rate on emissions (t_1) and the country's non-renewable energy consumption (E_i) by the tax rate on energy (t_2).

$$T_i = t_1 CO_{2i} + t_2 E_i$$

These tax rates are such that half of total revenue comes from CO_2 and half from energy:

$$\sum_i t_1 CO_{2i} = \sum_i t_2 E_i = 0.5 * T$$

Given the constraint that fiscal revenues are the same as in 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 oil equivalent. Unlike the previous model, this one not only taxes nuclear energy, but is also structured differently so as to reduce the differences between the tax burden imposed on coal, petroleum, and natural gas.

In the third tax model, we consider again that fossil fuels are taxed proportionally to their carbon content, but now the fiscal burden on nuclear electricity is considerably increased. The tax on nuclear electricity is established 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 EU 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

TOE of nuclear energy), so the substitution of nuclear energy for the energy coming from thermal power stations could not yield a fiscal saving in any country.

Under this third design, tax revenues from each country (T_i) are computed by multiplying the country's CO_2 emissions (CO_{2i}) by the tax rate on emissions (t_1) and the country's nuclear energy (NUC_i) by the tax rate on nuclear energy (t_2).

$$T_i = t_1 CO_{2i} + t_2 NUC_i$$

where $t_2 = t_1 * 4.31$, and $\sum_i T_i = T$ as in the first (and the second) design.

Taking into account the constraint that fiscal revenues are the same as in the first model, the tax that penalizes nuclear energy implies a lower burden on CO_2 emissions than in the first model (the tax rate on CO_2 is now 38.5 euros per ton).

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 Scheer (2001) in that the current situation of fiscal exemption for these fuels in the EU 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.

4.3. 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. However, taking this fact into account would require using much more complex models.

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.[5] The relationship between per capita GDP and the tax burden for the different countries is not very significant, however, the figure shows mildly regressive impacts that are smaller in the third tax design.

[TABLE I]

[FIGURE 1]

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 complex to explain because they depend on a multitude of factors: productive structures, models of transport, energy efficiency, etc...

[TABLE II]

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 less penalized, while the users of natural gas would not be as favored (in relation to other fossil fuels) as in the first model.[6]

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 very significant way. The result is that France and Sweden, the countries most favored by the first tax, now have a fiscal burden from the tax 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]

The negative signs of the results confirm that the considered taxes could 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 less rich 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]

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 Reynolds-Smolensky index, which measures the redistributive capacity of the tax and whose values are bounded between 1 and -1.[7] The positive values indicate a decrease in inequality while the negative values indicate an increase in inequality. 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]

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.

4.4. 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 more than a tax, the measure could be characterized as a bonus-penalization system or a "*feebate*" system (Weizsäcker et al. 1997): 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 per capita EU mean. 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, as we said before, the lump-sum redistribution could be considered equivalent in its redistributive effects *among countries* to a hypothetical additional public expenditure benefiting to all the countries of the EU in a quantity exactly proportional to their population.

In table V 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]

The effect of the 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 regressive redistributive effects among different population sectors inside each country, which also 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]

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

[TABLE VI]

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.

4. 5. Dynamic effects of the tax

The previous calculations are, in our opinion, an interesting first approach to the distributive effects of a European energy tax among different countries. The work is especially interesting in the light of how few studies of this issue have appeared. However, the approach is a static one, in the sense that it considers the “fiscal burden” that a specific tax would imply for any country assuming that emissions (and the demand on the different energy sources) would be the same as in the reference year (1999). The conclusion would hold if emissions variation was proportional in all countries, which is also a very restrictive condition.

In order to account for dynamic aspects, the analysis would need to be based on the emissions (and energy demand) expected once the tax had been implemented. These emission levels would be influenced by several factors, and specifically, by the implementation of the energy tax itself. In fact, the main objective of the tax is just to bring about a reduction in emissions.

A simple conventional way of approaching this issue is to depart from the concept of marginal cost of emissions mitigation. In this section we will refer to the case of a pure tax on CO_2, although the reasoning would be similar for the other two cases.

Let us assume that a tax on CO_2 emissions t is implemented and that each country reduces its emissions while the marginal cost of doing so is lower than the tax. Let $MC(R_i)$ be the function of the marginal costs of reducing emissions in one unit, where R_i represents the share of reduction in respect of the emissions without the tax (baseline), and let us assume that $MC(0) \geq 0$ and $\frac{\partial MC(R_i)}{\partial R_i} \geq 0$. Thus, each country i would reduce its emissions from the level that would exist without the tax up to the point in which the marginal costs of reducing emissions would be equal to the tax, which is to say, $MC(R_i) = t$. Let a_i be the solution for R_i of this equality and x_i the state's emissions in the absence of the tax. Then, the emissions would be reduced by a quantity $y_i = a_i * x_i$.

A first problem of this approach is that a simple function of pollution mitigation costs does not account for the fact that the influence of a tax (even if implemented immediately) on the evolution of emissions would be mostly in the medium and long term; in fact, mitigation costs depend strongly on the time profile of the mitigation. Also, given the different energy taxation patterns across the EU countries (some of which already include a specific CO_2 tax), the implementation of a European CO_2 tax would not necessarily imply that the entire tax amount would be added to that from pre-existent taxes. In fact, in some countries, the effective tax on some sources of energy could increase by less, remain the same, or even diminish.

Leaving aside these problems, and others which we will address later, we can conclude from this model that the relative fiscal burdens would deviate in respect of those computed in the previous section to the extent that the values a_i are different for the different countries.

Furthermore, the introduction of the concept of pollution mitigation costs suggests another possible indicator of the "cost" that the tax considered in the previous sections entails for a country. It would consist of the sum of the "fiscal burden" and the "total cost of emissions mitigation" (minus, lump-sum transfers, where applicable).

Departing from the same marginal costs function, we obtain that the “total cost” (TC_i) for a country i would be:

$$TC_i = t(x_i - y_i) + \int_0^{a_i x_i} MC\left(\frac{y_i}{x_i}\right) \partial y_i$$

where y_i is the emissions reduction.

The relative total cost for the different countries would deviate in respect of the relative fiscal burdens since the function of marginal cost ($MC(R_i)$) is different between these countries; it will remain unchanged if the function is the same for all the countries. Under this second assumption, the relative burdens computed in the former section would hold. Although the assumption of equal marginal costs between countries is very restrictive (even more restrictive than the equality of a_i values), this is the hypothesis that some authors have assumed in their studies for all world countries (and not just for EU countries). This is the case of the analysis by Larsen and Sha (1994) of the potential effects of an international market of CO_2 emissions' rights. Similarly, Nordhaus (1991,1994) extrapolates the estimations, most of which were based on the United States economy, for the function of the marginal costs of global mitigation at world level.

A practical difficulty for quantitative estimations accounting for the different costs of pollution mitigation is that the few studies which do exist reach very different conclusions. As an extreme example, the studies cited in Hourcade et al. (1996, figure 9.10, p. 318), point to Spain as having the highest marginal costs, while Viguier et al. (2003, figure 16) consider it to be the country with lowest marginal costs, although both coincide in considering Italy as a country with high costs.

Furthermore, there is the problem of establishing the reference point for this marginal cost, and therefore, for the “total cost”: a reference point that assumes that no policy is simultaneously applied to mitigate climate change, one that incorporates the decisions and projects already applied in each country, or one that incorporates the measures needed in order to accomplish some previous commitments?

But, beyond these practical difficulties, the appropriateness of the theoretical concept of the function of (monetary) CO_2 emission mitigation costs can also be questioned. Although the idea that the “difficulties” faced by different countries in reducing emissions are different is, of course, sound, the concretion of these “difficulties” into a monetary value raises many doubts. Firstly, because the existence of the win-win possibilities identified by several studies (especially bottom-up studies) proves that it cannot be assumed that all the opportunities for reducing emissions at no cost are not being exploited (or that in the case of implementing a tax, that these opportunities would be taken and the process would be ordered and logically sequenced from less to more cost marginally). The more efficient the initial scenario is assumed to be, the higher the computed costs. The existence of non-maximizing behaviors and fiscal distortions, which could be reduced by “recycling” the revenues, provides a possibility for double dividend (IPCC, 2001). The “recycling” would vary the costs of mitigation and provides a possibility for negative –or very low- mitigation costs.

Secondly, “difficulty” is not simply equivalent to monetary cost, as shown by the fact that some countries (such as Spain and Germany) subsidize coal mining, and these subsidies are difficult to do away with despite the negative economic cost this would represent. Thirdly, the same emissions mitigation policy might affect future technologies, undoubtedly also affecting the future relative cost of different options, which has not been satisfactorily modeled (Hourcade *et al*. (1996)).

In addition, while the concept of “fiscal burden” is perfectly defined in monetary terms, the concept of the monetary cost of emissions mitigation at macroeconomic level is problematic, or at least, much vaguer. Although there are many estimates of the effects of ecotaxes on GDP, what is really important is the analysis of the effects on the welfare of the population.

It must also be highlighted that mitigation policies have secondary benefits, in some cases comparable to the mitigation costs (IPCC, 2001), without considering the same positive effects of mitigating climate change. These benefits are mostly public health benefits due to reductions in the emissions of harmful particles.

Consequently, although it is possible to list a series of qualitative aspects that determine the different economic and social effects that the same tax would have in different countries —due to the different efforts or difficulties involved in emission mitigation—, obtaining a precise numeric calculation of the future fiscal burden or, even worse, the total cost, would imply a series of arbitrary choices between alternative assumptions. Therefore, future research should analyze potential development of the relative fiscal burdens under various scenarios. Furthermore, even if analysis of the relative fiscal burdens did take into account forecasts incorporating the possible dynamic effects, we do not think that the concept of "fiscal burden" should be diluted in the much more problematic concept of "total monetary cost".

The IPCC (2001) highlights some of the aspects of the different "difficulties" for reducing emissions encountered in different countries. Firstly, the use of low carbon emission energies. The higher this use, the lower the potential for changing to less CO_2 intensive fuels. This could be the case of France, where nuclear energy accounts for 40% of total energy supply, or Sweden, because of the high weight of both nuclear energy and renewable energies. At the opposite extreme, we find Greece, Ireland and Portugal because of the high weight of coal, crude oil and petroleum products. These countries have greater potential for switching to less CO_2 intensive fuels. The carbonization index in table II is a first synthetic indicator of capacity to change to less carbon-intensive fuels although it must not be forgotten that the potential to switch also depends on the specific type of energy use: changing is generally easier in the electricity generation sector than in private transport, for example. While some countries would be initially less burdened, in relative terms, than others by the CO_2 tax, due to their predominant energy sources, this difference would very likely tend to diminish due to the higher potential for changing to less CO_2 intensive fuels for other countries.[11] In principle, given the higher weight of CO_2 intensive fuels in some of the European countries with lower per capita income, it might be expected that the regressivity (among countries) will diminish over time.

Secondly, economic growth. On the one hand, the quick capital turnover provides opportunities for the installation of low-carbon technologies. On the other hand, energy requirements generally rise with economic growth. As a consequence, fast-growing economies tend to reduce their energy intensity, but total emissions rise significantly. This is the case of Ireland, which is experiencing the highest growth rates, and to a lesser extent also of Greece and Spain. For these countries, a net reduction in emissions in respect of a reference year would be more costly. In any case, in dynamic terms, the reduction in energy intensity would reduce the relative burden (GDP percentage) that the tax would entail in these countries.

Thirdly, energy intensity. High energy intensity may mean that a country has not yet applied the policies that have been applied in other countries. However, it could also indicate that an economy is more specialized in energy-intensive activities and might therefore experience difficulties in changing to a less energy-intensive model in the short term. Among countries with higher energy intensity are Belgium, Finland, Sweden, Spain and Portugal (see Table II).

5. Conclusions

In the present paper we have analyzed what would be the redistributive impacts among the different countries of the EU 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 harmonized mixed tax CO_2/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 EU intercountry distribution 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 the most interesting one in equity terms.

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Notes

1. One could think that in the case of the international tax an important incentive would exist to "hide" emissions (Hoel 1992). However, in the specific case of CO_2 emissions, whose value is directly related to energy consumption, these possibilities would surely be quite limited. Anyway, it is a difficulty that has to be overcome for any international policy that imposes obligations and potential penalizations to different countries.
2. 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".
3. 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).
4. 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.

5. Population data have been taken from IAE (2001) and GDP data have been taken from Eurostat (2001).
6. 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 released.
7. We do not use the original formulation of the Reynolds-Smolensky (1977) but the “reformulated” index, which measures more properly the redistributive effect in case of reranking of income units (Lambert 1993).
8. In the case of a tax that penalizes nuclear energy the conclusions vary, as it would clearly affect more those countries where nuclear energy accounts for a large share of total energy supply.

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Table I. Fiscal burden (% of GDP) that would represent different tax options according to the assumptions detailed in the text (year 1999)

		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

Source: own elaboration from IAE (2001) and Eurostat (2001) data (see text for methodology).

Table II. Intensity in carbon dioxide emissions (year 1999)

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*

Source: own elaboration from IAE (2001) data (see text).

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

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

Table V. Fiscal burden (as % of GDP) that represents each tax after lump-sum transfers (year 1999)

		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

Source: own elaboration from IAE (2001) and Eurostat (2001) data (see text for methodology).

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

Figure 1. Tax burden (as % of GDP) of the different tax options

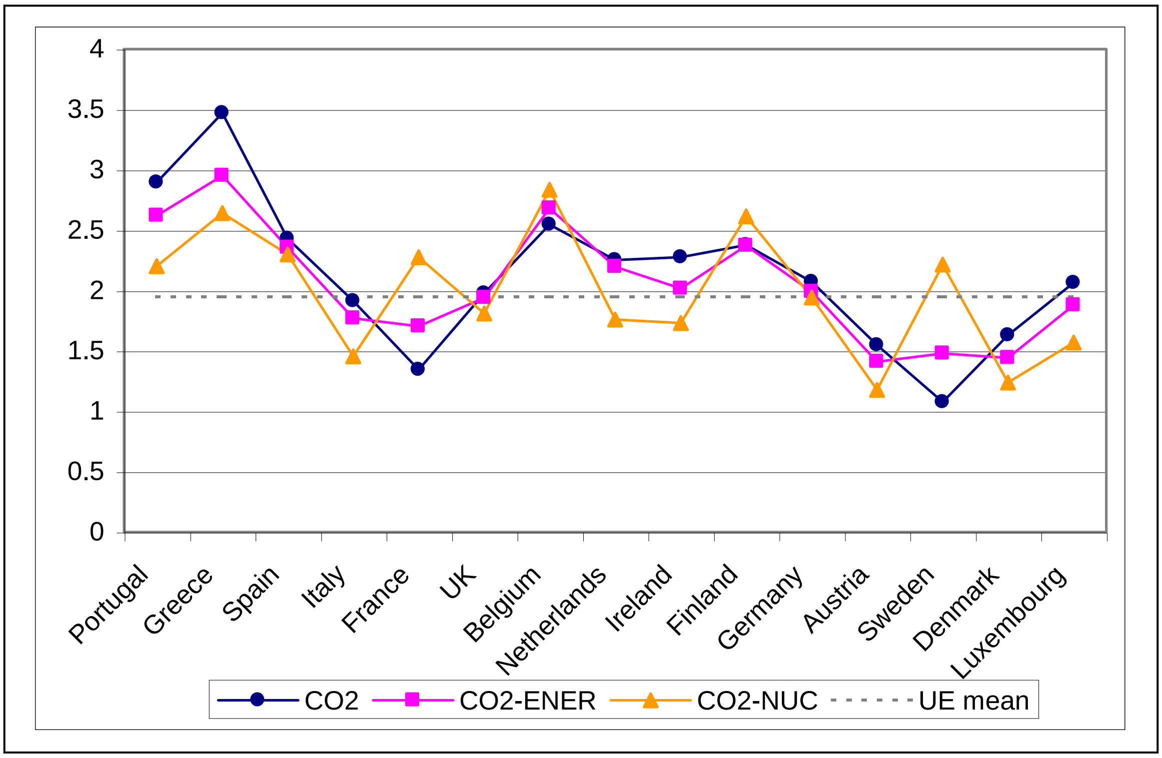

Figure 2. Lorenz curve and fiscal concentration curves of the different taxes

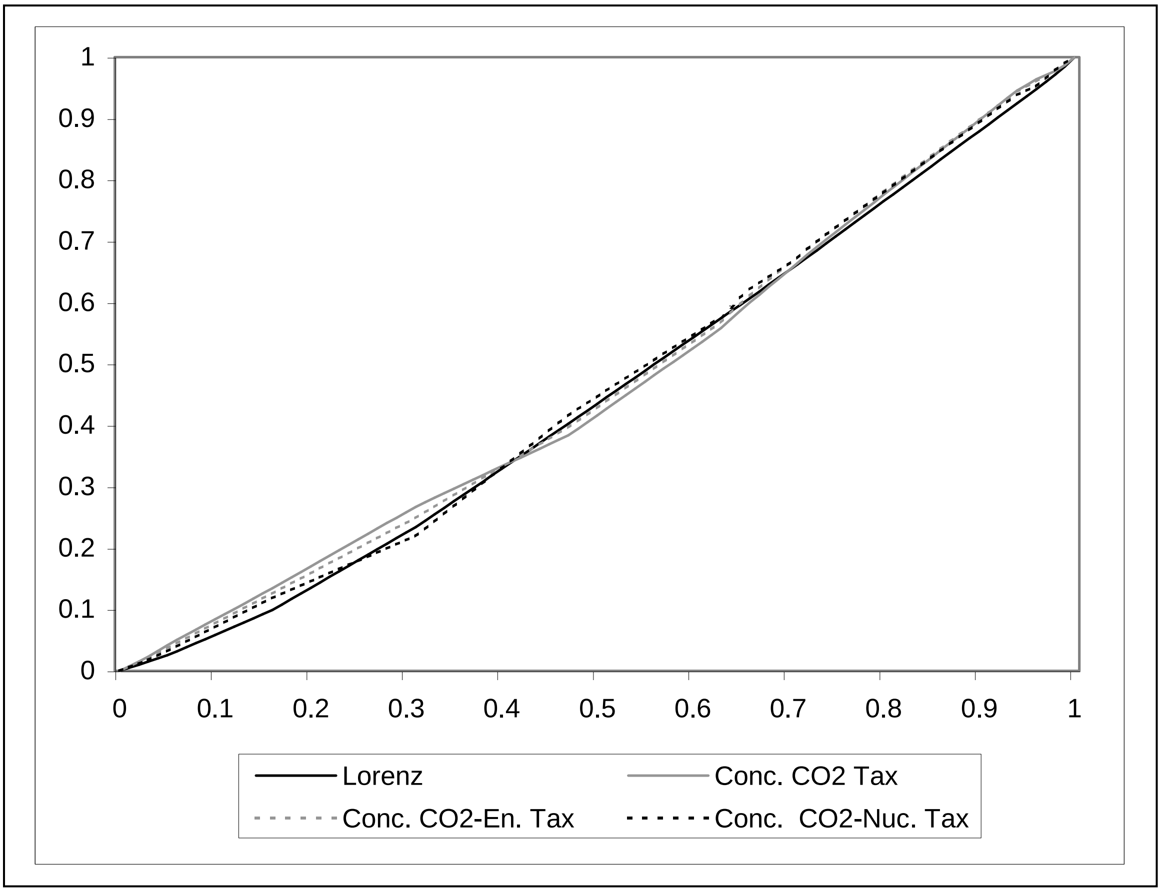

Figure 3. Fiscal burden (as % of GDP) of the tax net of lump-sum transfers