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AN INSTRUMENT OF LIMITING CARBON EMISSIONS:CARBON TAX

Doç.Dr.Sahin Akkaya*

l-Introduction

Water vapour and the greenhouse gases-carbon dioxide,chlorofluorocarbons,methane, nitrous oxide and ozone –permit the sun's radiation to reach the earth surface,but have trapping effect on the earth's outbound radiation,this trapping effect is known as the greenhouse effect (Cline,1991,p.904).Because of this greenhouse effect,the average earth's temperature increases and this increase leads to global warming.In other words,even though there are many scientific uncertainties about the greenhouse effect and we don't have enough knowledge about the costs of global warming,we know,for the time being,the accumulation of greenhouse gases in the atmosphere increases and this increasing accumulation leads to changes in global climate.

The most important greenhouse gas made by humanbeing is carbondioxide.For this reason,to deal with the global warming problem,we should slow down carbon dioxide emissions.In order to control this gas emission,there are two basic control instruments:global carbon tax and global tradeable carbon dioxide permits.Because in this paper on carbon tax,aiming to examine the main characteristics and some effects of the tax,we left a study on the theory and political economy of a carbon tax to our another paper.This paper is divided in three sections.Section 2 describes the main characteristics of a carbon tax.Section 3 provides an overview of some recent studies on carbon tax in order to give some insights in understanding the effects of a carbon tax.The last section is a summary section.

2-What is a Carbon Tax?

The imposition of a Pigouvian tax,equal to the difference etween marginal social cost and private marginal cost increases social welfare through internalizing the externality into private costs.Because an environment tax aims to internalize the negative externality caused by polluting activities into private costs,this tax is a Pigouvian tax (Barthold, 1994 ,p.135). The carbon tax ,as an environment tax is an externality-correcting device aiming to internalize the negative global externality

* Istanbul Üniversitesi, Iktisat Fakültesi, Maliye Bölümü Ögretim Üyesi.

associated with carbon dioxide emissions into private costs.Because the imposition of the carbon tax on fossil fuels equalizes the marginal social costs of reducing carbon emissions equals to the marginal social benefits of slowing down the global warming,atmosphere will be efficiently utilized in respect to carbon emissions(Herber and Raga,p.259).

In order to control carbon dioxide emission efficiently,the carbon tax should be proportional to the carbon content of each fossil fuel.For example,coal contains more carbon than natural gas,in other words,coal burned emits more carbon dioxide per unit of energy than natural gas.In this reason,the tax on coal should be heavier than that on natural gas.(Poterba, l991,p.52 and Pearce,1991,p.945.). On the other hand,whether the tax levels on fossil fuels should be changed over time is related to the stock of carbon dioxide in the atmosphere(about this problem,see Ulph and Ulph,1994 ;and Sinclair,1994).

In order to capture the negative externality associated with carbon dioxide emissions,a carbon tax base should be defined in specific,not ad valorem terms.Since the physical amount of fuel used to produce energy is linked to carbon emissions, a carbon tax may been harmonized across countries by the destination principle of international trade.Moreover,this principle helps reduce trade distortions (Herber and Raga,1995,pp.257-258).

Even though a carbon tax is an environment tax,imposed to internalize the negative externality associated with carbon dioxide emissions,it raises the total tax revenue.On the other hand,firms and consumers will resist any new tax and politicians are reluctant to impose a new tax like a carbon tax.If a carbon tax is introduced as a package of fiscally neutral measures like reducing distorting taxes such as income tax or payroll tax,this enhances the acceptability of a carbon tax.Governments taking attention to this double dividend feature[1] may use the carbon tax revenue to reduce distorting taxes(Pearce,1991,p.940).

The function of a carbon tax,proportional to carbon content of fossil fuels is to substitute less or non-carbon emitting energy sources for oil and coal.In other words,this tax leads to use less fossil fuels.Because global warming is a global problem affecting all people in the world, the solution for this negative global externality needs international coordination.Unilateral national carbon emission abatement policies make reaching the efficient carbon emission level in the world impossible.There are several reasons for this result(Poterba,1993,pp.48-49).First of all,each country acting alone doesn't take attention to the benefits that accrue to other countries.Second reason is that it is impossible to stabilize carbon emission for

[1] There is an increasing literature in the double-dividend feature of environment taxes.As an introduction to the "double dividend" issue,see Goulder(1995).On the other hand,for one of the last studies on the double dividend issue,see Holmkund and Kolm(2000).

a single country,Thirdly,due to international competition,it is not easy to pursue a policy a policy in order to reduce carbon emission level for a single country.The last one is that unilateral national policies doesn't reach the least-cost result of reducing carbon emission.

However,international coordination is needed to achieve the effective solution of limiting carbon emission,coordinated international action in order to accept an international carbon tax doesn't seem possible.Generally,international coalitions for environmental problems are voluntary in nature,a single country benefitting from an international environmental aggrement,participate in the aggreement,otherwise doesn't participate(see for the details in the international coordination,Barrett,1994).

The reduction in carbon dioxide emissions is achieved by the differences in the level of the tax on fossil fuels,e.g.coal ,and natural gas.A carbon tax is one of the least-cost policies in order to slow down global warming.But ,there is a suspicion about the economic effectiveness of the carbon tax(Kaufmann,1991).For example,in some countries and some sectors,the interfuel substitution toward natural gas is offset,in part,by the substitution of oil for natural gas.Because of this last substitution,the economic effectiveness of a carbon tax is reduced..Interestingly,the increase in the price of natural gas relative to oil is the result of the carbon tax and of course,this price increase brings about the unexpected substitution.The increase in the price of natural gas relative to oil mainly in the industrial sector affects significantly the economic effectiveness of a carbon tax.

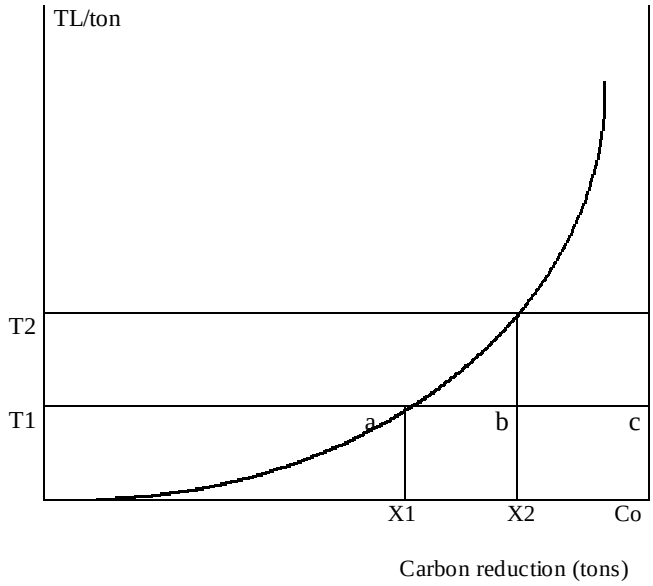
This tax has distributional effects like all taxes.The argument about that a carbon tax burden will be borne by low-income families is based on the fact that the ratio of consumption for the fuels to income declines as the income rises.But,if a carbon tax burden is analyzed relative to lifetime income, not to current income,the regressivity of this tax declines(Poterba,p.56).

If the costs of limiting carbon emissions are much greater than that of global warming,we can say that it is rational not to levy a carbon tax to reduce carbon emissions.For this reason,it is very important to have data about the costs of carbon tax.

In order to estimate the costs of limiting carbon emissions,the economic models start from a target carbon emission level and then estimate of the carbon tax required to reduce emissions to this target level. The cost of limiting carbon emission is linked to a carbon tax level and the tax level is bound to the target emission level.The reduction in gross national(or domestic) product(GNP) due to the carbon tax depends on the substitution elasticities of the particular model(Cline,1992,pp.146-147).

It is possible to show the usual relationship between the carbon tax level and its economic cost by the figure below.

Figure 1: Carbon tax level and economic cost



Source: Cline(1992)p.148

In the figure,the horizontal axis reads the number of tons of carbon cut(X)and the limiting carbon emission may reach up to a maximum of the entire initial carbon level(Co).Co shows the entire initial carbon level.The vertical axis shows the tax level in order to reduce carbon emission to the level required.For example,a cutback of X1 tons requires a tax of T1.

The tax curve which is nonlinear here is the tax curve showing the opportunity cost of the carbon.The area labeled by a equals the total economic cost caused by a carbon tax of T1 .On the other hand,the tax revenue coming from the tax of T1 is shown by the area of (b+c).This area is measured by (T1(Co-X1)).

3.Some Recent Studies on Carbon Tax

In this section, because aiming to give some insights in understanding the effects of a carbon tax,we provide an overview of some recent studies on carbon tax.

Manne and Richels(1991)

They explored how the costs of limiting carbon dioxide emissions are likely to vary among regions of the world.Their model uses 1990 base year statistics.71 % man-made carbon emissions originated from the industrialized countries in 1990.The projections made include 11 ten-year time intervals through 2100.In this study,it is assumed that the USA,other OECD countries(Western Europe,Canada,Japan,Australia and New Zealand),former Soviet Union and Eastern Europe agree to stabilize carbon emissions at their 1990 levels by the year 2000,and the degree by degree reduce them by 20% thorough the year 2020.They assume further that the developing countries,China and the rest of the world,accept the limitation about their emissions to double their 1990 levels by the year 2020.In the light of these limitations,the main results of the study are as follows:

-In the absence of an international aggrement,carbon emissions are likely to increase considerably.

-In the USA,from 2000 by 2030,the cost of the carbon constraint is 3% of the total annual US.GDP.

-For the other OECD countries cited above,after the year 2010,they bear annualy 1-2 % of the total consumption as a consequence of the carbon limitations.

-Former Soviet Union and Eastern Europe bear more burden than the USA and the other OECD countries.Their cost is equal to 4 % of their total consumption.

-China's lost exceeds annualy 10% gross domestic product(GDP) by the second half of the 21st century.

-The rest of the world including OPEC(Organization of the Petroleum Exporting Countries),Mexico and other potential oil exporters bear a lost annualy 5% of GDP from 2020 to the end of the 21st century.

-In order to achieve 20 % reduction of the carbon emission of 1990 levels,long-run equilibrium tax level is $ 250 per ton carbon.Because of this tax,international price of petroleum rises to $90 per barrel.

Jorgenson,Slesnick and Wilcoxen(1992)

This study analyses the effect of a carbon tax on equity in the distribution of lifetime welfare in the United States.In order to estimate the effect of this tax on the distribution of welfare among households,an intertemporal general equilibrium model of the U.S.economy is employed in the study.The tax revenue coming from a carbon tax doesn't affect government spending.The revenue is used to reduce the average tax rate on labor income to hold the government deficit constant,but marginal tax rate on labor income isn't changed.In the study,a utilitarian social welfare function is employed .In order to stabilize carbon dioxide emissions at the 1990 levels, a carbon tax is imposed.For example,this tax level is $17,65 per ton of

carbon in the year 2020.This means a carbon tax of $11,46 per ton of coal,$2,41 per barrel of oil,etc.The basic results of this study are as follows:

-Social welfare decreases because of a carbon tax.

-For this tax increases the prices of fossil fuels and changes the relative prices of all commodities,firms and households substitute away from fossil fuels leading to different expenditure patterns

-This carbon tax is regressive in the relative sense,but this regresivity is extremely small in the U.S.economy.

Nordhaus(1993)

This study employing a dynamic integrated climate-economy model(DICE model)analyses the effects of different greenhouse gas reduction scenarios specified for the United States.The DICE model includes two important functions;the climate-damage function and the greenhouse gas-reduction cost function.There are two alternative control strategies in the study.One of them is called as the optimal policy aiming to maximize the objective function.Secondly,the study analysis the effects of 20% emissions reductions from 1990 levels.The results of the study are as follows:

-For the optimal policy,required carbon tax level is $5,24 per ton carbon and the emission control rate is 8,8 %.The tax level rises and reaches about $20 per ton carbon by the end of the 21st century

-For the second alternative ,the emission control rate is 30,8 %.This alternative requires a carbon tax of $55,55 per ton carbon.having a net annual costs of $ 762 billions.

-If the tax revenue coming from a carbon tax which the optimal policy requires,is used to cut the taxes having excess burden,the optimal control rate rises from 8,8% to 31,7 % and the optimal carbon tax level rises from $5,24 to $59 per ton carbon in the first ten years.A net annualized gains rise from $16,39 billions to $ 205,97 billions.

Kverndokk(1993)

This study assumes that the world has agreed on a treaty to reduce carbon dioxide emissions by 20 % of 1990 level from the year 2000 to 2100.The cost-effective approach requires that the abatement costs should be minimized by a tax (or another instrument)toreach the target emission level.The main results of the study are as follows:

-The cost-effective approach requires the highest carbon dioxide reductions should be taken by the regions with the lowest abatement costs.This leads to that

Western Europe,Canada,Japan,Australia and New Zealand take the bulk of the reductions after 2000.

-The abatement costs are relatively high in the developing countries,due to large reserves of domestic coal,limited energy substitution possibilities and rapid economic development.Therefore,the developing countries are allowed to increase their emissions above the 1990 levels.

-Because a uniform carbon tax equalizes the marginal abatement costs of reducing carbon dioxide emissions,this tax leads to the least-cost reductions of carbon dioxide emissions.The tax level is $600-700 per ton carbon in the first half of the 21st century and $300 per ton carbon in the year 2100.

-For the cost effective reduction of carbon dioxide emissions to reach a target emission level,compared to a uniform percentage reduction minimizes total abatement costs, the choosing cost-effective approach leads to the total gains up to 20% off in costs in the beginning of the 21st century.After the year 2030,the gains from reductions in costs fall significantly.

Gaskins and Wegant(1993)

In this study,six basic control scenarios specified for the United States, are analysed.These control scenarios use the same gross domestic products(GDP),population,resource availability,and technology assumptions,but considered different levels and rates of carbon dioxide emissions control .A number of general results of the scenarios specified in order to control carbon dioxide emissions,are as follows:

-Carbon taxes will generate substantial tax revenues These extra tax revenues could be used for a number of purposes like reducing other taxes and financing budget deficit.

- It is possible to reduce emissions significantly from their non-controlled level without substantial GDP losses.

-On the other hand,the GDP losses could be reduced substantially by using the carbon tax revenues to reduce existing taxes which have excess burden

-Because of a carbon reduction program implemented unilateraly by one country or a group of countries,changes in international energy prices will cause carbon emissions in other countries to increase relative to non-control levels.This result shows the importance of a cooperative and multilateral carbon-reduction program.

Bull,Hassett and Metcalf(1994)

Because they stressed the importance of the measure of the tax burden in terms of lifetime incidence ,their study aims to measure the lifetime incidence of energy taxes like carbon tax. This study assumes that a carbon tax (or another energy tax) is shifted entirely to consumers.The study stresses that for measuring the

lifetime incidence of a carbon tax of $ 5 per ton carbon,it is required to capture all effects(both direct and indirect) on distribution.While increasing the price of energy sources is the direct effect,increasing the price of all other goods in proportion to the energy used to produce them is the indirect effect.The main result of the study is that because of direct impact of the tax,this tax has regressive effect on distributional grounds,on the other hand,when the total effect is taken into account,this tax is roughly proportional.

Berg,Kverndokk and Rosendahl (1997)

In this paper,the effects of a constant international carbon tax of $ 10 per barrel of oil($ 90,3 per ton of carbon) on oil market are studied. .A constant international carbon tax of $ 10 per barrel of oil equals $ 90,3 per ton of carbon. Because all fossil fuels should be taxed according to the carbon content,the carbon tax of $90,3 per ton of carbon is levied on all fossil fuels.It is possible to give the main results of the study as follows:

-A constant international tax will reduce global carbon dioxide emissions especially in the long run. A carbon tax of $ 10 per barrel of oil increases carbon dioxide emissions to 9,2 billion tonnes ,compared to 11,6 billion tonnes without carbon tax in 2050.

-This tax level reduces the producer price of crude oil by $ 0,2 per barrel and.the consumer price increases by $ 9,8 per barrel in the first period.This means the tax burden is initially born almost completely by the consumers.The reason for this result is decreasing total oil production,not the elasticity of oil demand.Because OPEC(Organization of the Petroleum Exporting Countries) acts as a cartel,it reacts to the carbon tax by restricting its production.By the year 2030,the carbon tax is mainly tipped over to the consumers .After 2040,the tax burden is born completely by the oil producers.It means,after 2040,the consumer price of the oil is going to be constant.

-There is an interesting result linked to the above that the oil wealth of OPEC is reduced by 23% because of the carbon tax.

-For the tax lowers the maximum producer price after the year 2100,to produce coal doesn't make sense.

Barker(1999)

This study measures the effects of a carbon tax in the 11 member states of the European Union .He assumes the revenues from carbon taxes are used to keep the total tax revenues constant and each member state reduces employers taxes in the form of contributions to social security schemes,i.e,carbon tax is a tax-revenue neutral device in order to control carbon emissions.In order to reduce carbon emissions 10 % below baseline (the baseline is defined 7 % above 1990 levels by

2010 for the 11 member countries)from 1999 to 2010 carbon tax is used The main results of this study are as follows :

-For the 11 EU member states,the carbon tax revenues as a proportion of GDP in current prices rise from 0,4 % of GDP in the year 2000 to 2,2 % by 2010.This result is the outcome of the 2010 rates of tax .For the year 2010,to reduce carbon emissions 10% below baseline,the carbon tax of 156 Ecu/ton carbon is needed for multilateral coordinated policy in 1999 prices This overall tax level rises to 162 Ecu/ton for multilateral uncoordinated policy.

-Another result is almost all member states(except the Netherlands) benefit from a double dividend feature of the carbon tax.Employment rises by 1,2%(1,3 in the uncoordinated case)and GDP rises by 1,4%(1,5 in the uncoordinated case)compared to the base case,that is without the carbon tax.

4-Conclusion:

The most important greenhouse gas ,leading global warming is carbon dioxide.For this reason,we should slow down carbon dioxide emissions.A carbon tax as an environment tax is one of the instruments to reduce carbon dioxide emissions to an efficient level.

The carbon tax is a tax on the fossil fuels.This tax should be proportional to the carbon content of each fossil fuel in order to control carbon dioxide emission efficiently.For coal contains more carbon than natural gas and oil,the tax on coal should be heavier than that on oil and natural gas.In addition,a carbon tax as a Pigouvian tax, should equalize the marginal social cost and marginal social benefits associated with the global warming problem.But ,it is very difficult or impossible to measure what the optimal carbon tax level is in practice.

Because all taxes have distributional effects,does a carbon tax too.The direct impact of a carbon tax is negative on distributional grounds.But it is possible to reduce the regressivity of the carbon tax by cutting payroll tax or money transfers to low-income families.Esspecialy,the use of the carbon tax's revenue to cut payroll tax has two positive effects:reducing distorting effect of the payroll tax and mitigating the regressivity of the carbon tax.

On the other hand,global warming is a global problem affecting all people in the world.For this reason,the solution for this global externality needs international coordination.Generally,international coalitions for environmental problems are voluntary in nature.If a single country benefitting from an international environmental aggrement,participate in the aggreement.In order to draw the countries burdening more from reducing greenhouse effect policy into the coalition,it is needed some compensation instruments such as aid,for a successful coalition.Even though international coalition to adopt an international carbon tax

seems impossible,some countries,such as Finland and Sweden,have carbon tax on fossil fuels.

Because the effects of a carbon tax depend on the tax level,the tax revenue coming from the carbon tax,the elasticities of substitution,the degree of competition esspecialy in the fossil fuel markets and e.t.c.,we should evaluate cautiously the results of the studies overviewed above.

The last thing we should say that because some taxes on fossil fuels limit yet carbon dioxide emissions,we don't forget the carbon limiting effect of these taxes when measuring the carbon limiting effect of replacing of existing taxes on fossil fuels with a carbon tax .

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