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Article — Digitized Version

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Intereconomics

Suggested Citation: Zhang, ZhongXiang; Folmer, Henk (1995) : The choice of policy instruments for the control of carbon dioxide emissions, Intereconomics, ISSN 0020-5346, Nomos Verlagsgesellschaft, Baden-Baden, Vol. 30, Iss. 3, pp. 133-142, <https://doi.org/10.1007/BF02927268>

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ZhongXiang Zhang and Henk Folmer*

The Choice of Policy Instruments for the Control of Carbon Dioxide Emissions

Increasing concern in scientific and policy-making circles about the possibility of global warming induced by the accumulation of CO₂ and other greenhouse gases in the atmosphere has promoted the consideration of policies to limit emissions of these gases.

This paper gives an overview of policy instruments targeted at the control of CO₂ emissions, including the command-and-control approach, energy taxes, carbon taxes and tradeable carbon permits, with special attention being paid to the economic instruments.

In recent years there has been increasing concern about global warming as a result of increased atmospheric concentrations of the so-called greenhouse gases (GHGs) and the overall socio-economic impact of any resulting climate changes. Although there are still uncertainties regarding the magnitude, timing and regional patterns of climate change, there is a growing consensus in scientific and policy-making circles that climate change and instability are very likely over the next century.

The GHGs are carbon dioxide (CO₂), chlorofluorocarbons (CFCs), methane (CH₄), tropospheric ozone (O₃) and nitrous oxide (N₂O). According to the World Resources Institute, CO₂ emissions alone contribute about half the present global warming and thus form the major cause of the greenhouse effect. This dominance of the CO₂ contribution to global warming suggests that CO₂ must be the main target in any attempt to limit emissions of GHGs. For this reason, we limit ourself to a discussion of the problems of control of CO₂ emissions.

Policy instruments targeted at the control of CO₂ emissions include the command-and-control approach, energy taxes, carbon taxes, and tradeable carbon permits.

Before dealing with policy instruments targeted at the control of CO₂ emissions, however, we pause

briefly to consider why the targets for emission reductions need to be predefined.

According to the conventional theory of environmental economics, there is no need to set the targets for emission reductions beforehand when the associated externalities are internalized. The optimal emission level is achieved when the point is reached at which the marginal cost of reducing emissions is the same as the marginal cost of the damages. So long as the so-called Pigouvian tax is set equal to the marginal cost of the damages, its implementation automatically leads to the optimal situation. This means that the process of internalization itself co-determines the target. However, this principle works better for conventional environmental problems than those problems with international and intertemporal dimensions (e.g. acid rain, ozone layer depletion and climate change), an essential feature of which is the absence of an institution with the international jurisdiction to enforce policy.¹ This also has consequences for the formulation of policy, including the revelation of costs and benefits.

Given the characteristics of these problems, we need to reconsider a separate approach that was first proposed by Baumol and Oates:² setting emission reduction targets first and then selecting instruments to achieve these targets at the least cost. Compared with the conventional approach where the

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¹ Cf. H. Folmer, P. van Mouche and S. Ragland: International Environmental Problems and Interconnected Games, in: Environmental and Resource Economics, Vol. 3, 1993, pp. 313-335.

² W. J. Baumol and W. E. Oates: The Use of Standards and Prices for Protection of the Environment, in: Swedish Journal of Economics, Vol. 73, 1971, No. 1, pp. 42-54.

optimal solution is sought, effectiveness is the goal for the Baumol-Oates case, in which there is nothing to indicate that the level of emission reduction achieved by the separate approach is either the economic or even the environmental optimum.

It has been observed that the two most important international agreements on limiting emissions of atmospheric pollutants – the Montreal Protocol on CFCs and the European Community's Large Combustion Plant (LCP) Directive to limit acid emissions – have been formulated in this way. The Montreal Protocol calls for a 50% reduction in CFC emissions by the signatory countries by 1999, with a grace period of ten years for developing countries. The LCP Directive incorporates a complex formulation of SO₂ and NO_x reduction levels for three target dates, with different elements of backdating for each member country.

With the conclusion of these two major agreements based on percentage reduction targets for gaseous emissions, it is not surprising that calls for limiting CO₂ emissions have focused on a similar strategy. The Toronto Conference recommended a 20% reduction by 2005 and a 50% reduction by 2025 in global CO₂ emissions relative to the 1988 levels, with an initial goal set for a 20% cut by 2005 in the industrialized countries.

The acceptable reduction targets can be set by scientific expertise or international agreement. Whatever the acceptable carbon reduction target that is eventually set, the remaining issue is how it is to be achieved. In this regard, there are four alternative policy instruments: the command-and-control approach;³ energy taxes; carbon taxes; and tradeable carbon permits.

With regard to the global warming problems, especially in the CO₂ context, a number of recent studies discuss market-based instruments or economic incentive instruments, namely energy taxes, carbon taxes and tradeable carbon emission permits. It is argued that these economic instruments to limit CO₂ emissions can achieve the same target at lower costs than the conventional command-and-control regulations. Moreover the economic instruments can act as a continuous incentive to search for a cleaner technology, while for the

command-and-control regulations there is no incentive for the polluters to go beyond the standards unless the standards are continually revised and set slightly above the best available technologies. Therefore, the economic instruments have a *technology-forcing* characteristic. Some evidence shows that this dynamic efficiency aspect of economic instruments is important.⁴ In the CO₂ context, the dynamic efficiency takes on an extra dimension because, unlike sulphur, CO₂ is difficult to dispose of, even if it is removed from stack gases, and incentives to develop disposal technologies are therefore of particular relevance.⁵

In what follows, our attention is restricted to the economic instruments in the CO₂ context, namely energy taxes, carbon taxes and tradeable carbon emission permits.

Energy Taxes versus Carbon Taxes

An energy tax is an excise tax, which is expressed as a fixed absolute amount of e.g. US \$ per Terajoule. It is a tax placed on both fossil fuels and carbon-free energy sources according to their energy (or heat) content, with renewables usually being exempt. By contrast, a carbon tax (an excise tax that is imposed according to the carbon content of fossil fuels) is restricted to carbon-based fuels. Given that oil and gas have greater heat content for a given amount of CO₂ emissions than coal, an energy tax falls more heavily on oil and gas than a carbon tax. Moreover, an energy tax burdens nuclear energy, which, with the exception of hydropower, provides the only so far proven method with enormous potential for the large-scale generation of electricity without direct parallel production of CO₂ emissions.

If the goal is to reduce CO₂ emissions, a carbon tax is preferred on grounds of cost-effectiveness, given that a carbon tax is able to equalize the marginal costs of CO₂ abatement across fuels and therefore satisfies the condition for minimizing the costs of reducing CO₂ emissions. This implies that an energy tax (if introduced) would lead to poor target achievement or else to unnecessarily high costs as compared with a carbon tax. This can be further explained by two factors: first, price-induced energy conservation; and secondly fuel switching. Carbon taxes reduce

³ In the international CO₂ context, this approach includes the widely discussed uniform percentage reductions in emissions by all participating countries. In this case, individual countries would be left to reduce their CO₂ emissions by traditional command-and-control regulations, tradeable carbon emission permits for domestic sources, or domestic carbon taxes.

⁴ Cf. T. H. Tietenberg: Economic Instruments for Environmental Regulation, in: Oxford Review of Economic Policy, Vol. 6, 1990, No. 1, pp. 17-33.

⁵ D. Pearce: The Role of Carbon Taxes in Adjusting to Global Warming, in: Economic Journal, Vol. 101, 1991, pp. 938-948.

CO₂ emissions both through their price mechanism effects on energy consumption and through fuel choice. By contrast, since an energy tax is imposed on both fossil fuels and nuclear energy, the incentive for fuel switching will be reduced, and the reductions in CO₂ emissions will be achieved mainly by price-induced energy conservation. Thus a higher tax is required for achieving the same reduction target as compared with the carbon taxes. Put another way, for the economy in question it is more costly to reduce CO₂ emissions through an energy tax than through a carbon tax. This has been clearly shown in the study by Manne and Richels,⁶ which evaluates the implications of the CEC proposal for a mixed carbon and energy tax.⁷ A similar finding is also presented in the study by Jorgenson and Wilcoxon, the results of which suggest that the US GNP loss in 2020 from an energy tax is 20% greater than that from a carbon tax to stabilize the US CO₂ emissions at 1990 levels in the year 2020.⁸

Let us now turn to the carbon tax. So far, a number of studies have focused on the cost estimates for achieving a given reduction in CO₂ emissions. These studies usually incorporate a carbon tax as a method of achieving the target because of its effectiveness. The main findings arising from these studies are:

- the carbon tax should escalate over time if it is to reflect the rising costs of damage from the accumulation of CO₂ concentration in the atmosphere and if it is to give the markets the signal that CO₂ emissions will eventually be heavily taxed;
- there would be significant variation in the timing and size of the carbon taxes among countries and regions, given that the marginal costs of abating CO₂ emissions differ substantially across countries and over time;
- the carbon tax could be production or consumption based, but the effects across options would be significantly different among countries. A national production based carbon tax operates much like an export tax, and if it were applied oil-exporting

countries such as OPEC would gain substantially, but in a national consumption based tax case, they would become significant sufferers;⁹

□ the carbon taxes imposed unilaterally or even regionally would be largely ineffective. This ineffectiveness is attributed partly to the relatively small share of coalition (e.g. EC, OECD) emissions in the world total and partly to strong economic growth and the resulting increase in emissions taking place in non-coalition countries that offset the coalition's achievements;¹⁰

□ the autonomous (i.e. non-price-induced) energy efficiency improvement, the possibilities for fuel substitution, and the availability of backstop technologies¹¹ are essential. Without non-fossil fuel options, the upper bound on the carbon tax required rises. Moreover, the autonomous energy efficiency improvement, and the cost and availability of low-carbon or carbon-free backstop technologies are crucial to limiting the tax level required. Where there are few economically feasible substitutes available, the effectiveness of a carbon tax is likely to be much lower. Thus, to lower CO₂ emissions very substantially would require a large carbon tax – larger certainly than the taxes already implemented. This would lead to high costs induced for compliance with the emission reduction targets; and

□ the carbon tax itself would impose a deadweight loss on a country where there are no distortions in the energy markets. But when existing distortions arising from energy subsidies are taken into account or when the revenues generated from the imposition of a

⁶ Cf. A. S. Manne and R. G. Richels: The EC Proposal for Combining Carbon and Energy Taxes: The Implications for Future CO₂ Emissions, in: *Energy Policy*, Vol. 21, 1993, No. 1, pp. 5-12.

⁷ As part of its comprehensive strategy to control CO₂ emissions and increase energy efficiency, a carbon/energy tax has been proposed by the Commission of the European Communities (CEC). The CEC proposal is that member states introduce a carbon/energy tax of US\$ 3 per barrel oil equivalent in 1993, rising in real terms by US\$ 1 a year to US\$ 10 per barrel in 2000. After the year 2000 the tax rate will stay at US\$ 10 per barrel in 1993 prices. The tax rates are allocated across fuels, with 50% based on carbon content and 50% on energy content.

⁸ Cf. D. W. Jorgenson and P. J. Wilcoxon: Reducing U.S. Carbon Dioxide Emissions: An Assessment of Different Instruments, in: *Journal of Policy Modeling*, Vol. 15, 1993, Nos. 5&6, pp. 491-520.

⁹ Cf. J. Whalley: The Interface between Environmental and Trade Policies, in: *Economic Journal*, Vol. 101 (1991), pp. 180-189; J. Whalley and R. Wigle: The International Incidence of Carbon Taxes, in: R. Dornbusch and J. Poterba (eds.): *Global Warming: Economic Policy Responses*, MIT Press, Cambridge 1991, pp. 71-97.

¹⁰ This phenomenon is the so-called carbon leakage, with its average leakage rate defined as the ratio of carbon emission *increase* outside the coalition to carbon emission *cutbacks* within the coalition relative to their reference levels. For further discussion, cf. S. Felder and T. F. Rutherford: Unilateral CO₂ Reductions and Carbon Leakage: The Consequences of International Trade in Oil and Basic Materials, in: *Journal of Environmental Economics and Management*, Vol. 25, 1993, pp. 162-176.

¹¹ Nordhaus defines a backstop technology, in the context of energy supply, as an energy technology based on a resource for which there are no resource constraints. In an economy based on such an energy backstop technology, the economic importance of the scarcity of exhaustible energy resources disappears, and capital and labor costs alone determine energy prices. Cf. W. D. Nordhaus: *The Efficient Use of Energy Resources*, Yale University Press, New Haven 1979, p. 11.

carbon tax are recycled to the economy to replace another indirect tax, the introduction of a carbon tax could even lead to a net gain.

We will not go further into these interesting topics. Instead, we will focus on three aspects that are considered to be important when designing a domestic carbon tax.

Domestic Carbon Tax Design

The three aspects to be addressed below are: the treatment of carbon tax revenues, the impacts on the distribution of income and the effects on international competitiveness.

We begin with the treatment of the carbon tax revenues. It has been argued that there is a "double dividend" from the carbon tax:¹² not only an environmental dividend through reduced emissions of pollutants but also a non-environmental dividend in terms of a reduction in the overall economic cost of raising government revenues.¹³ This "double dividend" feature of a carbon tax has important implications for "green tax swaps" for distortionary taxes. If the objective of a carbon tax is to reduce consumption of carbon-based energy products through the reallocation of spending away from CO₂-emitting activities, and thus to slow down (or even stabilize) the build-up of atmospheric CO₂ concentration, rather than for macroeconomic management, the carbon tax is in essence an incentive tax rather than a revenue-

raising tax. In macroeconomic terms it therefore seems appropriate that revenues raised through an increase in one indirect tax (a carbon tax) could be offset by a reduction in another indirect tax e.g. value added tax (VAT) so as to minimize the effect on the general level of prices. The inflationary and indeed all the highly uncertain macroeconomic effects of the carbon tax would be reduced to a minimum.¹⁴ Another measure used to recycle all revenues from the carbon tax to the economy is a reduction in income tax. If it is adopted, inflation is then likely to increase, although the extent of acceleration depends on the attitude of

¹² Cf. D. Pearce, op. cit. In the recent study by Goulder, the weak "double dividend" and the strong "double dividend" are distinguished. The weak "double dividend" proposition states that in welfare terms the non-environmental dividend is always positive as a reduction in distortionary taxes is always superior to a reduction of lump-sum taxes. In the strong "double dividend" proposition, it is stated that the non-environmental dividend is larger than the gross costs. If the strong claim held, it would reduce the amount of information that policy analysts need to make a cost-benefit case for green tax swaps. For further discussion, cf. L. H. Goulder: Environmental Taxation and the "Double Dividend": A Reader's Guide, Department of Economics, Stanford University 1994.

¹³ The non-environmental dividend is very often interpreted as using the extra carbon tax revenues to reduce existing distortionary taxes for raising government revenues. This dividend can of course have other interpretations. In the study by Bovenberg, for instance, reduced unemployment is referred to as the potential extra dividend in addition to improved environmental quality. For further discussion, cf. A. L. Bovenberg: Environmental Policy, Distortionary Labor Taxation, and Employment: Pollution Taxes and the Double Dividend, Center for Economic Research, Tilburg University 1994.

¹⁴ T. Barker, S. Baylis and P. Madsen: A UK Carbon/Energy Tax: The Macroeconomic Effects, in: Energy Policy, Vol. 21, 1993, No. 3, pp. 296-308.

Bernhard Fischer (ed.)

Investment and Financing in Developing Countries

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1994, 236 p., paperback, 58,- DM, 452,50 öS, 58,- sFr, ISBN 3-7890-3209-3
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wage negotiations to the increases in disposable income from the reduction in income tax. This higher inflationary response has been found in the modelling of the effects of the CEC tax.¹⁵ Alternatively, if the carbon tax revenues are retained in treasury coffers in order to reduce public sector deficits, then this will depress the economy, certainly in the short term. If the revenues are all spent by the government, for example, on non-fossil energy investment, this would imply a large investment programme which could lead to macroeconomic imbalance and rapid inflation.¹⁶

Distribution of Income

The second aspect of domestic carbon tax design is its impact on the distribution of income. A carbon tax would have a regressive impact on the distribution of income since lower income households spend a larger proportion of their income on energy than higher income households. Smith¹⁷ calculates the distributional effects of a mixed carbon and energy tax of \$10 per barrel in the UK on different income groups. The results show that the poorest 20% of the population would pay an additional £1.45 per week in tax, the richest 20% an additional £2.95 per week in tax, and the average household an additional £2.21 per week in tax. Translated into increases in tax paid as a percentage of total spending, these figures are equivalent to 2.4%, 0.8% and 1.4% respectively. Clearly, the relative burden of the additional tax would be higher for the poorest decile, and lower for the richest. This highlights that unless low income groups are to be made worse off by the carbon tax, a large part of the revenues from the tax will need to be used to compensate them through the use of tax reductions and increases in social security benefits and pensions. Unfortunately, the use of the carbon tax revenues in this way will reduce the scope for the revenues to be used to maximize the efficiency gains from reductions in other existing distortionary taxes such as VAT which were described above. There is thus a clear trade-off between efficiency and equity in the use of the revenues: the efficiency gains can only be achieved by sacrificing the distributional neutrality of the package.

The above findings are typically shown in the studies for the industrialized countries. Shah and Larsen¹⁸ argue that such findings cannot be generalized for the developing countries, where the incidence of carbon taxes would be affected by institutional factors. Among some important factors that may have a bearing on the tax-shifting are market power, price controls, import quotas, rationed foreign exchange, the presence of black markets and tax evasion and urban-rural migration.

International Competitiveness

Now we consider the third and last aspect, namely the effects on international competitiveness. A domestic carbon tax has important implications for the international competitiveness of economies in relative terms. Although international competitiveness is not necessarily reduced over the long term by higher energy prices, in certain industries the effects of introducing a unilateral carbon tax may be serious in the short term. Exemptions from the new taxes are therefore suggested to protect the price competitiveness of these industries in international trade. For example, the CEC proposal provides for exemptions for the six energy-intensive industries, iron and steel, non-ferrous metals, chemicals, cement, glass, and pulp and paper. As discussed earlier, a carbon tax is intended to fall most heavily on the products of carbon-intensive industries. Clearly, the exclusion of these industries from coverage of the carbon tax on grounds of competitiveness reduces the effectiveness of the carbon tax in achieving its objective of reducing CO₂ emissions,¹⁹ while it also means that the EC industries most vulnerable to competition are protected in their markets. The ineffectiveness of EC unilateral action suggests that at least similar actions in competitor countries, especially in the United States and Japan, should be taken (or some more general OECD-wide tax should be adopted), although carbon taxes need to be imposed globally in order to achieve sufficient reductions of CO₂ emissions.

So far our discussion has been restricted to domestic carbon tax. It has been argued that even if

¹⁵ F. Laroui and J. W. Velthuis (eds.): *An Energy Tax in Europe*, SEO, Amsterdam 1992, pp. 27-63 and 127-152.

¹⁶ Cf. T. Barker et al., op. cit.

¹⁷ S. Smith: *Distributional Effects of a European Carbon Tax*, Nota Di Lavoro 22.92, Fondazione Eni Enrico Mattei 1992.

¹⁸ A. Shah and B. Larsen: *Carbon Taxes, the Greenhouse Effect, and Developing Countries*, Policy Research Working Papers No. 957, The World Bank 1992.

¹⁹ In addition to this limitation, there are two additional problems. The first is that the industries which are exempt from paying the CEC tax will improve their competitive position in relation to those industries which are not exempt. There will therefore be some switching of demand towards the products of these energy-intensive industries, which is precisely the reaction that such a tax should avoid. The other problem is that firms which find themselves paying the tax will try to be reclassified as exempt or eligible for rebates if at all possible, thus limiting the impact of the tax on energy consumption and CO₂ emissions. See T. Barker et al., op. cit.

domestic emission reduction targets are achieved in cost-efficient ways, for example through a domestic carbon tax, a global cost-efficient emission reduction target can only be achieved if CO₂ emissions are distributed among countries in such a way that the marginal costs of abatement are equalized among countries. This global cost efficiency may be achieved through either an international carbon tax or a tradeable carbon emission permits regime. We shall first deal briefly with the former.

Hoel²⁰ has shown that a tax administered and collected by an international agency is too bureaucratic and would interfere with domestic sovereignty, while a tax implemented by each government would fall foul of the free-rider problem, since governments could easily offset a carbon tax by reducing other domestic taxes on fossil fuels. The way out has therefore to be one in which the carbon tax should be globally imposed on each country by some international agency but nationally administrated and collected. The carbon tax is set to be the same for each country. The revenues from the tax are then reimbursed, i.e. handed back to the countries where the revenues are raised according to some agreed rule of allocation. Each country would then act to minimize the sum of its tax payments and abatement costs. How, then, should the tax revenues be reimbursed? This is equivalent to the determination of the initial permits under a regime of tradeable carbon emission permits²¹. This issue will be discussed below.

Tradeable Carbon Emission Permits

An alternative to an international carbon tax is a regime of tradeable carbon permits, which allows the permit holders to trade or sell their entitlements to other countries. As long as the marginal costs of reducing CO₂ emissions differ among countries, the latter have an incentive to trade permits with the market price of CO₂ permits being equal to the

marginal costs of abatement, and make net gains. The process continues until the marginal costs of reducing CO₂ emissions are just equalized across countries, thus inducing a cost-efficient distribution of CO₂ emissions.

Once an international emission budget is set, the question then arises as to how to allocate the initial emission permits to each participating country.²² The obvious rules are based on both the costs of reducing CO₂ emissions and the consequences of climate change. The rules could be applied if the costs of abatement and the consequences of climate change were common knowledge. However, this is not the case.²³ In practice, these costs cannot be measured objectively with any precision, and there are still uncertainties regarding the magnitude, timing and regional effects of climate change. For this reason, the allocation of permits would in practice have to be based on relatively straightforward rules. In the CO₂ context, the rules based on uniform percentage reduction, existing CO₂ emissions (a grandfathering approach), current GNP (or GDP), and population, among others, have been suggested. The diversity of these allocation rules, each of which is discussed below, reflects the lack of consensus on a "best" equity principle.

A uniform percentage reduction offers an operational advantage because it focuses on easily observable physical burden-sharing. It is for this reason that international environmental agreements often take the form of a uniform percentage reduction. An example is the 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or Their Transboundary Fluxes by at least 30%.²⁴ In the CO₂ context, the rule ignoring the past build-up and simply basing reduction requirements on current emissions would be equivalent to penalizing developing countries for their economic development when no such penalty was imposed on industrialized countries for their abusing of the global commons in the course of their industrialization. Therefore it at least seems

²⁰ M. Hoel: Efficient International Agreements for Reducing Emissions of CO₂, in: The Energy Journal, Vol. 12, 1991, No. 2, pp. 93-108.

²¹ A carbon tax regime, in which total CO₂ emissions are equal to X and tax reimbursements to the n participating countries are proportional to the vector (a_1, a_2, \dots, a_n) with $\sum a_i = 1$, is equivalent to a regime of tradeable carbon permits, in which the initial permits allocated to the n participating countries are $(a_1X, a_2X, \dots, a_nX)$. See M. Hoel, op. cit.

²² *Ceteris paribus* entitlements defined in terms of emissions would be preferred; this would produce the most cost-effective outcome. With an emissions target the tendency of the market to seek the least cost means of control would be focused on reducing emissions, which, of course, is the objective. For further discussion, cf. P. Böhm: Incomplete International Cooperation to Reduce CO₂ Emissions: Alternative Policies, in: Journal of Environmental Economics and Management, Vol. 24, 1993, No. 3, pp. 258-271.

²³ The costs of reducing CO₂ emissions differ significantly across countries, depending among other factors on economic structure, product mix, fuel mix, current efficiency of energy use, and availability of backstop technologies. Moreover, given the huge uncertainties surrounding the magnitude, timing and regional effects of climate change, any estimates for the consequences of climate change for different countries must be speculative. Thus, if the allocation of initial permits were based on the rules, it would be in each country's interest to claim that it found reducing CO₂ emissions burdensome and climate change not very harmful. The negotiation process would be extremely difficult and it is doubtful where any agreement would be reached. This does not of course mean that there would be no difficulty of allocating the initial permits according to other rules which are to be discussed below. Cf. M. Hoel, op. cit.

conceivable that the rule would not be accepted by the developing countries. Moreover, it has been argued that the rule based on uniform percentage reductions is inefficient in the sense that the same goal could be achieved at lower costs through the rule that equalizes the marginal costs of abatement among all participating countries.

Using the grandfathering of permits or current GNP as a base would minimize the disruption of current production. However, using either rule as a base would favour the developed countries and does little or nothing to create incentives for the developing countries to co-operate. Moreover, there are some nasty wrinkles associated with adjusting the initial permits: should an energy-efficient country such as Japan be rewarded with additional permits? Should a country that relies on nuclear power and therefore is also a small emitter – like France – get extra permits? Should Brazil, whose copious forests absorb carbon dioxide, be rewarded for that? Also should countries that have unilaterally cut down their CO₂ emissions long before any CO₂ agreement be rewarded for that, where they would otherwise be punished?

Using population as a base is compatible with equal emission rights and could be accepted as fair by the developing countries. Given the great disparities in current per capita CO₂ emissions, however, this would probably imply net payments transfers from the developed countries to the developing countries on a substantial scale and therefore would not be easy for political leaders to justify. The study by Kverndokk²⁵ shows that transfers to the developing countries of 6% and 3% of their potential GDP in the year 2000 are required from the USA and other OECD countries respectively. The magnitude of these transfers is scarcely credible, when the United Nations' level of development assistance at 0.7% of

GDP is still not met by most of the industrialised countries. Moreover, as pointed out by Grubb,²⁶ the allocation rule might create an implicit incentive for countries to increase their population, whereas just the opposite is needed to address the greenhouse problem. Grubb suggests that only adults above a specific age should be counted in order to avoid the implicit reward for overpopulation.

Acceptable Allocation Regime

The foregoing discussion clearly indicates that the acceptability of tradeable permit regimes will depend on the allocation rules for permits. In view of the respective weaknesses of each rule discussed above, it follows that an acceptable allocation rule might take into account historical CO₂ emissions, GNP (or GDP) and population together, and that the emissions entitlements of each participating country should be adjusted over time in order to reduce the relative benefits and relative excess costs of each country. Pearce,²⁷ for instance, argues that an allocation regime based initially on grandfathering but with the emission permits being modified by altering the value of the permits over time, would be most appropriate. Thus, developed countries would have declining permits over time, while developing countries could have rising permits that less than offset the developed countries' reductions. This can be illustrated by, for example, the following formula:

$$Q_i = Q^g [w_H \Phi_{O,H,i} + w_Y \Phi_{O,Y,i} + w_P \Phi_{O,P,i}]$$

where i represents the country in question; Q is the emissions quota; superscript g is the global emissions target; subscripts H , Y , and P refer to historical CO₂ emissions, GDP, and population, respectively; w refers to the weight assigned to the rule, with the sum of w_H , w_Y and w_P being equal to one; Φ is the country's share in the relevant global total; and subscript O refers to the base year. This approach weights three alternative rules to determine an overall country permit. Cline²⁸ argues that if the three weights shifted

²⁴ With great concern about the long-range transboundary flow of sulphur and nitrogen oxides and the resulting regional-scale environmental damage (such as acidification of soil and fresh water and damage to vegetation), at a ministers' meeting in Ottawa, Canada, in March 1984, 10 nations volunteered to reduce emissions of sulphur dioxide by 30% by 1993 relative to their 1980 levels. This group of nations was referred to unofficially as the "30 Percent Club". By June 1984 membership in the "30 Percent Club" had increased to 18 nations. In July 1985 at Helsinki, Finland, a protocol to reduce sulphur dioxide emissions or transboundary fluxes by at least 30% was signed by 21 nations. Among the nations that did not sign the protocol were two of Europe's largest emitters: the United Kingdom and Poland. The former did not sign because, in its opinion, insufficient credit was given in the protocol for past emission reductions and because of the arbitrary choice of a base year (1980), whereas the latter did not sign the protocol because of its lack of technologies and equipment to control sulphur emissions. Cf. R. W. Shaw: Acid-Rain Negotiations in North America and Europe: A Study in Contrast, in: G. Sjöstedt (ed.): International Environmental Negotiation, SAGE, California 1993, pp. 84-109.

²⁵ S. Kverndokk: Global CO₂ Agreement: A Cost-Effective Approach, in: The Energy Journal, Vol. 14, 1993, No. 2, pp. 91-112.

²⁶ M. Grubb: The Greenhouse Effect: Negotiating Targets, The Royal Institute of International Affairs, London 1989. Given that there are many other problems associated with population growth, and that the governments are concerned with per capita income (or per capita welfare), it is highly unlikely that countries would increase their population for this reason. It is nevertheless worthwhile pointing out this possibility.

²⁷ D. Pearce: Economics and the Global Environmental Challenge, in: Journal of International Studies, Vol. 19, 1990, No. 3, pp. 365-387.

²⁸ W. R. Cline: The Economics of Global Warming, Institute of International Economics, Washington, DC 1992.

over time toward the population rule, and thus toward equity, the approach would seem to stand the best chance of support by both industrialized and developing countries: it would give great weight to the "realism" concerns of industrialized countries at the beginning of the period, but also provide large scope for a shift over time toward the equity concerns of developing countries.

Quantitative analyses of the effects of changing CO₂ permits over time along this line have been made, although relatively seldom. In the study by Manne and Richels,²⁹ for example, the carbon permits, though still benchmarked against 1990 as the base year, are distributed with grandfathering initially (the year 2000) but in proportion to the 1990 level of population at the end of the planning horizon (the year 2100). This allocation rule is designed not only to avoid an abrupt change in the status quo, but over the long run it also leads to an egalitarian distribution of carbon permits. The results show that according to the allocation rule there are no dramatic gains from

trade and each of the regions would *benefit modestly from trade*, since none of the five regions buys or sells more than 5% of the total global volume of tradeable carbon permits.

So far our discussion of the allocation rule is associated with a regime of tradeable carbon permits. These rules are also valid for determining how to reimburse carbon tax revenues if the international carbon tax is imposed across countries.

Carbon Taxes vs. Tradeable Carbon Permits

As discussed earlier, both carbon taxes and tradeable permits minimize overall abatement costs by allocating the cutbacks to the countries where the marginal costs of reducing CO₂ emissions are lowest. Moreover, given both perfectly competitive markets and certainty, carbon taxes are equivalent to tradeable permits. In practice, however, there are some differences between these two instruments.

Probably the most serious arguments in favour of tradeable permits rather than taxes so far are as follows:

- ☐ Tradeable carbon permits, unlike carbon taxes, are

²⁹ A. S. Manne and R. G. Richels: International Trade in Carbon Emission Rights: A Decomposition Procedure, in: American Economic Review, Vol. 81, 1991, No. 2, pp. 135-139.

Helen Winter

Interdependenzen zwischen Industriepolitik und Handelspolitik der Europäischen Gemeinschaft

It is worth analyzing the various and often subtle connections between industrial policy and trade policy, because these policies are becoming more important and they are used as substitutes or as complements to one another. After defining both policies and their relationships, the study examines the industrial and trade policy of the EC as a whole.

The key targets of industrial policy are to prevent or promote structural change and to improve international competitiveness. The various instruments of European industrial policy are designed to deal with international problems, but they also influence the trade relationships between other countries.

In addition to that, the EC uses trade policy instruments as some kind of industrial policy, or to protect industrial policy. This is sometimes cheaper as subsidies. But in some cases industrial policy substitutes trade policy because the application of traditional trade policy instruments is restricted by international agreements.

■ The book is published in German.

1994, 279 p., hardback, 89,- DM, 694,50 öS, 89,- sFr, ISBN 3-7890-3505-X
(Integration Europas und Ordnung der Weltwirtschaft, Bd. 4)

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a form of rationing and their great advantage is that in this way one can be sure of achieving the agreed target. By contrast, the actual achievements in reductions of CO₂ emissions for a proposed carbon tax remain uncertain because of imperfect knowledge of the price elasticities of demand and supply for fossil fuels, especially for the large price increases caused by carbon taxes for major emissions cutbacks.³⁰ This implies that setting the initial tax will be a hit-and-miss affair, and could thus induce hostile reactions from countries, industries, and consumers although it is not clear how serious an objection this is.³¹ Moreover, in the context of global warming, the delays in adjusting the insufficient carbon tax to the desired level will mean additional committed warming.

□ Another complication of the carbon tax is the initial differences in energy prices. As a consequence of existing distortions by price regulations, taxation, national monopolies, barriers to trade etc., there are initially wide differences in energy prices, both between fuels and across countries.³² If CO₂ emissions are then to be reduced by similar amounts in two countries, *ceteris paribus* lower taxes are required for the country with low prices before the tax imposition than for the country with the higher pre-tax prices. Thus a cost-efficient international carbon tax regime would presumably require the removal of existing distortions in international energy markets. Otherwise the countries with the lower pre-tax prices would enjoy free-ride benefits.

However, a regime of tradeable carbon permits is also subject to important limitations. In practice, the regime requires a sufficient number of traders (or participating countries) to avoid ill-functioning permit markets.³³ This requirement heightens the importance of wide participation by developing countries to avoid an insufficient number of traders. As discussed earlier, however, because of the great difficulty in allocating the initial carbon permits, it might take quite a long time to induce developing countries to join.³⁴ Moreover, even if the regime were put into operation, which might require less of an international bureaucracy

than would be needed to administer and enforce an international carbon tax, some supra-national agency would be required:

□ to regulate and perhaps periodically intervene in the permit market, in which some undesirable consequences may occur. Hoel,³⁵ for instance, argues that large countries can influence the prices of permits. For a larger seller, it is optimal to have higher carbon emissions than the level indicated by the marginal cost of abatement (i.e. the market price for permits); and the opposite holds true for a larger buyer;³⁶

□ to adjust the global target level and re-issue permits in response to changing conditions as discussed earlier; and

□ to monitor transactions and enforce any penalties for abuse.

All the administrative and transaction costs associated with tradeable permits cannot be known in advance. They may turn out to be much higher than was imagined when the target was defined, thereby making tradeable permits less of an attractive instrument. This uncertainty regarding the costs of emission reductions is an important distinction between tradeable permits and carbon taxes. Weitzman³⁷ has shown that, under specified conditions, if the marginal abatement cost curve is steeper than the marginal damage curve for emissions, then the costs of making an error in the selection of a price-based instrument such as an emission fee or charge will be less than those of making an error in the selection of a quantity-based

³⁰ For further discussion, cf. W. R. Cline, *op. cit.*

³¹ Cf. D. Pearce, *op. cit.*

³² P. Hoeller and J. Coppel: Carbon Taxes and Current Energy Policies in OECD Countries, in: OECD Economic Studies, Vol. 19, 1992, pp. 167-193.

³³ An international market seems a minimum requirement. Carbon emission permits, traded internationally, allow the marginal costs of abatement to be equalized across countries. Permits may be traded independently within nations so that the marginal costs of abatement are equalized across domestic sources.

³⁴ The 1987 Montreal Protocol on CFCs can be taken as an example. For CFCs, 1) there is substantial scientific evidence that CFCs play the greatest role in depleting the stratospheric ozone layer; 2) the number of key countries involved in the global production of CFCs, the overall economic costs of phasing out CFCs, and institutional changes involved are relatively small; and 3) the oligopolistic nature of the CFC-producing industry ensures that producers' cooperation could be secured by effective cartelization and limitation of production, making the monitoring of compliance not too difficult. Even for this case, which is far less complicated and costly than that of greenhouse emissions, it still took over ten years to achieve the Protocol. Cf. A. Enders and A. Porges: Successful Conventions and Conventional Success: Saving the Ozone Layer, in: K. Anderson and R. Blackhurst (eds.): The Greening of World Trade Issues, Harvester Wheatsheaf, New York 1992, pp. 130-144.

³⁵ For further discussion, cf. M. Hoel, *op. cit.*

³⁶ For a theoretical analysis of tradeable emission permits when some of the participants have market power, cf. R. W. Hahn and R. N. Stavins: Economic Incentives for Environmental Protection: Integrating Theory and Practice, in: American Economic Review, Vol. 82, 1992, No. 2, pp. 464-468; W. S. Misiulek and H. W. Elder: Exclusionary Manipulation of Markets for Pollution Rights, in: Journal of Environmental Economics and Management, Vol. 16, 1989, pp. 156-166.

³⁷ M. L. Weitzman: Prices vs. Quantities, in: Review of Economic Studies, Vol. 41, 1974, pp. 477-491.

instrument such as a tradeable permit. This suggests that if there is great uncertainty about the costs of emission reductions, carbon taxes are preferred in order to avoid potentially large and unexpected costs. However, if the overall impacts of climate change are believed to be unacceptably high or there were a threshold effect caused by the stock of CO₂ emissions beyond which atmospheric temperatures would rise exponentially, the target would then have high political priority. In this case, the choice of economic instruments should not be swayed by uncertainty regarding the costs of emission reductions, and tradeable permits would be preferred to carbon taxes.

Besides, so far there has been limited international experience with tradeable permits.³⁸ While tradeable permits have enjoyed some considerable success in the various domestic contexts, that by no means guarantees their success in the international context. Thus, such a regime is perhaps yet to be validated through more experience on a small, rather than global, scale. In this regard, it is worthwhile putting into practice *joint implementation*, a derivative of the idea of permits trading that has been built into the UN Framework Convention on Climate Change to allow countries to invest in emission reduction projects in other countries where such projects would be more cost-effective than trying to achieve an equivalent reduction within their own countries. The experiments may provide some experience for the implementation of a global tradeable emission permits regime.³⁹

Conclusions

This paper has evaluated policy instruments targeted at the control of CO₂ emissions. The following conclusions emerge from the analysis:

□ First, the global warming problem has international and intertemporal dimensions, where its impacts cannot be confined to the country of origin, will last over generations, and are hard to quantify. In dealing with such a problem, achieving the predefined targets for emissions reductions at the least cost is the goal, rather than seeking the optimal solution through internalization of the associated externalities.

□ Second, if the goal is to reduce CO₂ emissions, energy taxes (if introduced) will lead to poor target achievement or else to unnecessarily high costs as

compared with carbon taxes. In the case of general taxation on energy, the reductions in CO₂ emissions will mainly be achieved by price induced energy conservation. By contrast, carbon taxes reduce CO₂ emissions both through their price mechanism effects on energy consumption and through fuel choice.

□ Third, for the effectiveness of action, carbon taxes should escalate over time and be imposed globally in order to reflect the rising costs of damage from the accumulation of CO₂ concentration in the atmosphere, to give the markets the signal that CO₂ emissions will eventually be heavily taxed, and to prevent carbon leakage that would otherwise take place in regions or countries without such taxes. But if this is not the case, special attention should be given to the treatment of the carbon tax revenues, the impacts on the distribution of income, and to the effects on international competitiveness when designing a unilateral carbon tax.

□ Fourth, the allocation of emission permits would in practice have to be based on relatively straightforward rules. If an allocation rule is likely to induce relatively large participation, account might be taken of historical CO₂ emissions, GNP (or GDP) and population together, and the emission entitlements of each participating country should be adjusted over time in order to reduce the relative benefits and relative excess costs of each country.

□ Finally, the actual achievements in the reduction of CO₂ emissions for a proposed carbon tax remain uncertain, while under a regime of tradeable carbon permits there will be certainty about the magnitude of emission reductions but great uncertainty about the costs of such reductions. If there were a threshold effect of climate change, tradeable permits would be preferred to carbon taxes. Given our current lack of knowledge about the magnitude, timing and regional effects of climate change, however, carbon taxes appear to be the superior and more flexible instrument that avoids potentially large and unexpected costs.

³⁸ There are two main applications of tradeable permits: emissions trading under the US Clean Air Act and the use of individual quotas as the primary means of addressing overfishing and depletion of inshore stocks in New Zealand and other countries.

³⁹ Facilitating immediate progress without jeopardizing a smooth evolution to a more mature, comprehensive system requires careful attention to the implementation details. Although the *joint implementation* stage bears little resemblance to an actual emission permits market, it serves the very important purpose of launching the process and providing opportunities for the various supporting administrative institutions to "learn by doing". For further discussion of implementation issues for global tradeable carbon permits regime, cf. T. Tietenberg: Implementation Issues for Globally Tradeable Carbon Entitlements, in: E. van Ierland (ed.): International Environmental Economics: Theories and Applications to Climate Change, International Trade and Acidification, Elsevier, Amsterdam 1994, pp. 119-149.