CHOICE OF DOMESTIC POLICY MEASURES FOR THE CONTROL OF CARBON-EMISSION: FROM THE THEORETICAL AND EMPIRICAL PERSPECTIVES

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1 Introduction

The most frequently invoked criterion in emphasizing the superiority of the so called 'economic instruments' for the policy toward the control of carbon-emission is the 'efficiency'. Carbon tax is argued to achieve cost-effective allocations of abatement efforts[1] Cost-effectiveness is also claimed with regard to 'emissions trading', which is an alternative economic instrument.

This superiority is, however, only claimed on theoretical grounds. The crucial point is that the cost-effectiveness of an allocation of abatements is hinged on the equality of marginal abatement costs among emission sources. This condition is fulfilled under tax or emissions trading but only *theoretically.*

In the last decade, we have observed introductions of tax measures for reducing carbon-emissions in several countries, and now we find some proposals for introducing carbon-emissions trading. What we have to do now is to examine whether the alleged advantage of economic instruments can also be claimed on empirical grounds or not, and, if not, to make clear in what respects economic instruments are still to be favoured or whether other instruments such as command and control become to be fovoured in any respect or not.

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[1]Here, we are dealing only with the so called Baumol-Oates type of environmental tax. The Pigovian tax, distinguished from the Baumol-Oates tax, can be regarded as achieving not only cost-effective allocations of abatement efforts but also an optimum level of abatement (or pollution) in the sense that it brings about the maximum net benefits. The Pigovian tax is, however, unrealistic in the context of the climate change because of the virtual impossibility of the measurement of the marginal damage cost of carbon-emission or the marginal benefit from its reduction. Therefore, we do not deal with the Pigovian tax in this paper.

In the following section, I will illustrate some actual cases of economic instruments for carbon control and extract some implications. In section 3, I will evaluate policy measures on the basis of the observations.

2 Actual policy instruments

2.1 Carbon taxes in Europe

Carbon taxes have been introduced in the Netherlands, Norway, Finland, Sweden and Denmark.

2.1.1 The Netherlands

The Environmental Tax on Fuels in the Netherlands consists of C-general tax and C-limited tax (Nihon Enerugi-Keizai Kenkyusyo, 1997). The C-general tax is levied on almost all energy consumption, although reduction in tax rate and tax exemption have been introduced for several energy-intensive sectors. The C-limited tax is imposed solely on domestic and small-sized energy consumption (gas-oil, kerosine, liquified petroleum gas, natural gas and electricity). Both C-general and C-limited taxes consist of a part of carbon-based tax and a part of energy-based tax.

Table 1: Tax rates in the Environmental Tax on Fuels in the Netherlands

	Carbon-based tax Dfl/t-CO2 (US$/t-C)	Energy-based tax Dfl/GJ (US$/GJ)
C-general tax	5.16 (11.22)	0.3906 (0.232)
C-limited tax	27.00 (58.72)	1.506 (0.893)

The tax rates are shown in Table 1. The C-general tax rate for gasoline, for example, is Dfl 25.10/kl, of which 49% is the carbon-based part. The C-general tax rate for coal is Dfl 33.08/t, of which 40% is the carbon-based part. The C-limited tax rate for kerosine is Dfl 125/kl, of which 57% is the carbon-based part.

We can find several problems with the Dutch Environmental Tax on Fuels when we deal with this tax as a Baumol-Oates type carbon tax.

First, the tax per unit of carbon emission is not equal among different kinds of fuels because this tax includes the energy-based part. This would prevent the allocation of the efforts for carbon-reduction from becoming cost-effective. This is, however, not a very important problem because the inequality in the tax rate per carbon unit over fuels is not large.

The more important problem is the inequality in the tax rate among different sectors or, especially, among the energy-users with different sizes. First, with ragard to C-genral tax, reduction in tax rate and tax exemption for energy intensive industrial sectors have been introduced. A reduced tax rate is applied to the sectors with intensive use of natural gas. Severl fuels such as blast furnace gas are exempted. Second, the C-limited tax is imposed only on the energy consumption at households and small-sized industries (excluding energy for transportation). The tax is not levied, for example, on the consumption of gas-oil exceeding 153,000kl/year, of kerosine exceeding 159,000kl/year, of LPG exceeding 119,000kl/year, of natural gas exceeding 170,000kl/year and of electricity exceeding 50,000kWh/year. The lower limit is also made for natural gas and electricity, i.e, natural gas consumption below 800m^3/year and electricity consumption below 800kWh/year are exempted from taxation.

These tax reduction and exemption would distort the allocation of abatement efforts. The Dutch situation would be illustrated by Fig. 1. The differential tax rates are represented by the line ABCDE. Faced with these rates, an energy user with, for example, the marginal abatement costs (MAC) curve represented by MAC_1 would reduce its emission to q_1 at which the MAC is equal to the lower tax rate t_1. An energy user with MAC_3 would, however, reduce its emission to q_3 at which the MAC is equal to the higher tax rate t_2. An energy user with MAC_2 would reduce its emission to q_2 or to q_2' depending on whether the area DGH is larger than the area CFH or not, which would equalize the MAC to t_1 or

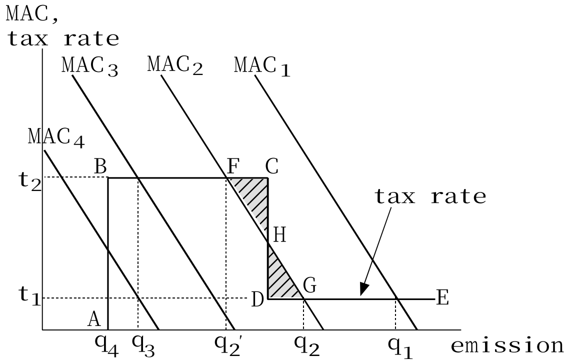

Figure 1: The allocative implication of the Dutch Environmental Tax on Fuels

t_2. An energy user with MAC_4 would reduce its emission to q_4 at which MAC would be equal to some value between t_1 and t_2.

The tax rate for energy-intensive users is so low that it would not give a sufficient incentive to reduce carbon emissions. In order to offset this flaw, long-term agreements on energy-saving have been made between the industries and the government. Such agreements, like regulations, would be effective to reduce carbon emissions, but they would not equalize marginal abatement costs.

In addition, further tax exemption contingent on investments on energy-savings is proposed by a government committee in order to produce more incentive to reduce carbon-emission without raising tax rates. When this proposal is realized, carbon-emission would be reduced, but marginal abatement costs would further dispersed and the resulting allocation would never be cost-effective.

2.1.2 Denmark

Carbon tax was introduced in Denmark in 1993 (Nihon Enerugi-Keizai Kenkyusyo, 1997; Oka 1997b). The tax rate is DKr 100/t-CO_2 (US$ 50/t-C), but this rate is only for households[2]. For industrial process energy, tax is levied at lower rates. The rate for light process energy is DKr 90/t-CO_2 (DKr 68 when agreement is made about improvement in energy-saving between the industry and the government). The rate for heavy process energy is DKr 25/t-CO_2 when there is no agreement on the improvement in the efficiency of energy use between the industry and the government, but DKr 3/t-CO_2 when such an agreement is made. When the industry does not fulfil the agreement, the rate will become DKr 25 again.

In Denmark, like in the Netherlands, the inequality in the tax rate would have produced the inequality in the marginal abatement costs. First, there is a large difference in the tax rate between the domestic sector (DKr 600) and the industrial sector (DKr 3∼90). Secondly, there is a discrepancy in the tax rate within the industrial sector. Thirdly, the fact that the lowest rate is applied contingent on the existence of the agreement would have produced further discrepancy in the marginal costs. Fig. 2 illustrates the situation. The agreed emission level is represented by q_0, the lower tax rate contingent on the compliance is t_1 and the higher rate for nonagreement case is t_2. The industry with the marginal abatement costs represented by MAC_1 would reduce its emission to the agreed level q_0 when the area CEF is smaller than the area ABCG, although MAC_1 crosses the tax line at a larger emission level q_1. The industry with MAC_2 would also reduce its emission to q_0. The tax combined with agreements, therefore, has a tendency toward convergence of emission levels and divergence of marginal costs.

[2]Additionally energy tax of DKr 500/t-CO_2 is imposed on the energy use at households.

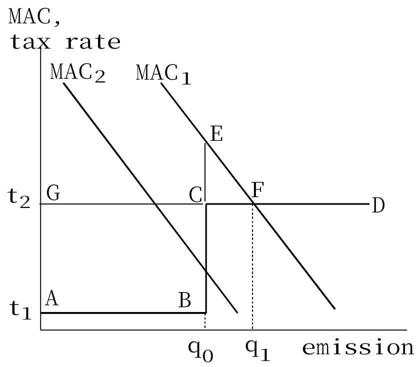

Figure 2: The allocative implication of the lower tax rate contingent on the agreement in Denmark

2.1.3 Sweden

Reduced tax rates for industrial energy use is also adopted in the Swedish carbon tax. The carbon tax was introduced in 1991 at the rate of SKr 250/t-CO_2 (US$ 108/t-C). This rate was regarded as sufficient to give incentive for carbon reduction. In 1993, the rate was raised to SKr 320/t-CO_2 (US$ 139/t-C), but the rate for industrial use was reduced to SKr 80/t-CO_2. In 1997 the rate for industrial use was raised to SKr 160[3] (Oka, 1997a).

2.2 Proposed carbon tax in Japan

In Japan, the Committee on Economic System for Tackling Global Warming issued a report in 1996, which assessed that carbon tax with the rate of 30,000 yen/t-C (US$ 270/t-C) would be sufficient to stabilize the nationwide carbon emission. This report also argued that 3,000 yen/t-C would be sufficient if all the tax revenue is appropriately recycled in order to encourage investments for carbon reduction.

The latter proposal was regarded as politically more feasible and it is as effective as the first one in achieving the target for carbon reduction. However, it cannot equalize the marginal abatement costs and it cannot realize cost-effective allocations of abatement efforts (Oka, 1997a).

2.3 Proposed 'greening' of existing taxes in Japan

In 1999, the Ministry of Transport and the Environment Agency proposed a 'greening' of automobile taxes. In Japan, there are two kinds of tax imposed on the holding of automobiles. One is the 'automobile tax', the tax base of which is the size of engine. The other is the 'weight tax', the tax base of which is the weight of automobiles. The present amount of the 'automobile tax' per year ranges from 29,500 yen to 57,000 yen depending on the size of engine, and the present rate of the 'weight tax' is 6300 yen for every 0.5t of automobiles.

The proposal was to differentiate these taxes according to fuel efficiency. It was proposed to reduce the amount of the 'automobile tax' by 5000 yen per year and the rate of the 'weight tax' by 1000 yen for the automobiles fulfilling the new fuel efficiency standards, which are to be applied in 2010, and to raise the 'automobile tax' by 5000 yen per year and the 'weight tax' by 1000 yen for the automobiles with fuel efficiencies below the present standards by more than 20%.

This greening of the automobile taxes would give incentives to purchase more fuel efficient cars and lead to reducing carbon emissions. It, however, is not a carbon tax, because the amount of tax is not proportional to carbon emission. Nor it is a Baumol-Oates tax to equalize marginal abatement costs to

[3]However, it is applied when the tax payment does not exceed 0.8% of the total sales. For the part that exceeds 0.8% of the sales, the tax rate is SKr 38.

reduce carbon emissions. It depends on the existence of the regulation of fuel efficiency. It would be fair to regard this greening as a supplementary measure to improve the performance of a direct regulation.

However, it has much more political feasibility than the carbon tax. That is because it could give as much incentive to reduce carbon emission through purchasing a more fuel efficient car as carbon tax would do with much less additional burden of tax-payment on car-users. Nonetheless, it has no more cost-effectiveness than a command and control has, because fuel efficiency standards are necessary for determining the threshold fuel-efficiency at which the tax rate is differentiated.

2.4 Keidanren Voluntary Action Plan on the Environment

Keidanren (Japan Federation of Economic Organisations), published the 'Keidanren Voluntary Action Plan on the Environment' in June 1997. Although this action plan is a unilateral commitment on the part of industries, it can be regarded as an agreement in that it constitutes a component of the Japanese Government's 'Basic Principles for the Promotion of Measures Dealing with Global Warming'.

According to this action plan, the goal is 'to endeavor to reduce CO2 emissions from the industrial and energy-conversion sectors to below the levels of 1990 by 2010.' Forty-one industrial end energy-conversion sectors have been participating the Action Plan. Most of the participating sectors have set quantitative targets: 18 sectors have set targets in terms of CO2 emission or energy-use per unit of output; 14 sectors have set targets in terms of abosolute quantity of CO2 emission or energy-use.

Follow-up review is to be done every year. According to the first follow-up review, the CO2 emission from 28 sectors, which were reviewed, was 133 million tonne, which represents an increase by 3.0% from the emission in 1990.

Although this voluntary action plan is like an agreement, it has a weaker binding power than a real bilateral agreement. However, it may actually be effective in reducing carbon emission from industrial sectors. Nonetheless, it would not achieve efficient CO2 reduction as any agreements and regulations do.

2.5 Proposed Climate Change Levy and carbon trading in the UK

The UK government proposed in 1999 the Climate Change Levy (CCL), which were to be introduced in 2001 (HM Costoms and Excise, 1999). This tax is to be levied on the energy consumption in the industrial and business sectors.

Table 2: Tax rates in the CCL (pence/kWh)

Type of energy	Tax rate (2001-02)
Electricity	0.43
Gas	0.15
Coal	0.15

Pre-Budget Report November 1999, Protecting the Environment.

Tax rates are as shown in Table 2. As the rate for gas is the same as that for coal, the amount of tax per tonne of carbon is not equal for gas and coal. The CCL is not levied on the energy consumed by households, nonprofit orgainzations and public transportations. Furthermore, a reduced tax rate (20% of the rates presented in Table 2) will be applied for the sectors which have agreed on standards of energy-saving with the government.

By the end of 1999, ten manufacturing industries reached agreement, which represent the majority of the energy use in the manufacturing sector in the UK (DETR, 1999). Since the number of the industries that reach agreement will increase, the reduced tax rate will become the mainstream of the CCL.

How much carbon emission is reduced at each energy user will be determined not with reference to the tax but to the agreement. Therefore, the fuction of the tax to make efficient the allocation of abatement efforts by equalizing the marginal abatement costs to the tax rate cannot be expected.

The CBI (Confederation of British Industry) and the ACBE (Advisary Committee on Business and Environment) of the government presented a plan for a system of the carbon emissions trading in 1999

(Emissions Trading Group, 1999). In this proposal, the carbon emission related to the agreed energy consumption in the CCL will become the emission permit that can be traded. When actual emission is smaller than the permitted amount, then the difference will become the credit that can be sold, and when actual emission is larger than the permitted amount, then the defficiency will have to be supplied by purchasing.

However, since permits are created by the agreements, the property of the agreements influence the property of the permits. There are two kinds of agreements. Some industries reach agreements on the reduction in the absolute amounts of carbon emitted, and the other industries reach agreements on the reduction in the rate of carbon emitted per some unit, e.g., in the amount of carbon emitted per tonne of annual production. According to the distinction, an industrial sector will become an 'absolute sector' or a 'unit sector'.

Initial allocation of the emission permits is the most intractable problem with regard to emissions trading because it means initial endowment of a newly created properties and because it would mean a property loss to be endowed the amount of permits corresponding to the amount less than that one has been emitting. Since emissions trading would be introduced usually for the purpose of reducing the total amount of emission, there must be emission sources who suffer property losses.

The CBI/ACBE's carbon trading program, however, seems to be able to solve this problem through allocating the initial emission permits according to the agreements on energy-saving. However, it is the existence of the 'unit sector' that makes the initial allocation less problematic. The unit sector industries can expand their activities even increasing their carbon emission, as long as they fulfil the agreement in 'unit' terms, while the 'absolute sector' industries have much more probability that they have to scale down their activities. The permits in the unit sector can, therefore, be inflated. The CBI/ACBE's proposal includes a limitation on permits trading from the unit sector to the absolute sector, but the total amount of permits can be inflated. This means the total amount of carbon emission might actually not be reduced.

2.6 Lessons from the actual cases

Let us summarize the observations from the actual cases of domestic policy measures for carbon-control:

1. There has not been an ideal carbon tax—'ideal' in the sense that where, how and how much carbon emission is reduced is determined at each emission source solely with reference to the tax, and that a uniform tax rate is applied that is sufficient to reduce the total carbon emission to a target level—.
   (a) All the actual carbon (or energy) taxes have insufficient tax rate to meat targets or have reduced tax rates for particular sectors (industrial sectors in particular) in order to reduce the tax burden or to reduce the loss in competitiveness of the sectors.
   (b) The reduction in tax rates is, in many cases, accompanied with some agreement on energy-savings or carbon-reductions. In this case, the methods and the amount of carbon-reduction at each source is determined with reference to the agreement rather than to the carbon tax.
2. Emissions trading is not free from the problem of initial allocation. Attempts to avoid this problem may lead to a failure to achieve targets for carbon-reduction.
3. 'Greening' of existing taxes is different in nature from the Baumol-Oates type of environmental tax, such as carbon tax. Such a 'greening' requires some kinds of thresholds, according which tax rates are differentiated. Those thresholds must be determined like standards in direct regulations. Therefore, one cannot expect no more cost-effectiveness for such a greening than for a command and control, although it has more political feasibility.
4. Agreements or regulations is effective for industrial sectors to realize actual reduction in carbon-emissions. Trading may be introduced when emission permits have been generated though such agreements or regulations, which would add efficiency to the achieved carbon-reduction. Those measures is not likely to be feasible for household and transportation sectors.

3 Towards choice of policy measures

1. A universal carbon tax that is levied widely on every sector's carbon emission would be infeasible.
2. For some industrial sectors, agreements or regulations may be effective for the purpose of reducing their carbon-emissions, but they cannot be expected to bring about efficiency. Emissions trading may be introduced in order to add efficiency to the achieved carbon-reduction, although the problem of initial allocation is persistent.
3. For household and transportation sectors, neither agreements nor regulation is feasible. Until now no determinate policy measure is presented for those sectors, but there may be three possible measures:

   (a) Carbon tax that is almost ideal but limited to the household and transportation sectors.

   (b) Introduction of various incentive measures such as greening the existing taxes and subsidy for investing in carbon-reducing activities.

   (c) Carbon trading.

   Let us examine these measures against the following criteria:

   (a) Reliability in achieving a target on carbon-reduction.

   (b) Cost-effectiveness or efficiency in achieving the target.

   (c) Political feasibility.

   Regarding reliability, carbon trading will be the best. Through limiting the total amount of emission permits within the target level, it can assure the achievement of the target. Carbon tax is unreliable in that actual extent of carbon-reduction is known only ex post. Extremely high tax rate would assure the achievement of the target, but it would lead to an over-achivement, which would not be appropriate for the purpose of carbon tax. In addition, such a high tax rate would be highly politically infeasible. Introduction of several incentive measures would not also have high reliability. However, in this measure incentives can be strengthen without reducing political feasibility. In this sense, reliability can be higher than carbon tax.

   Regarding cost-effectiveness, carbon tax and carbon trading are superior, and introducing several incentive measures is evidently inferior.

   With respect to political feasibility, introduction of several incentive measures is superior, and carbon tax is inferior. Taking into account the high transaction costs and the difficulty of initial allocation, political feasibility of carbon trading seems very low. However, there are several means to improve the political feasibility of these measures.

   With regard to carbon tax, the cause of the low political feasibility is the heavy tax burden on energy users. One way for lightening the burden is to reduce existing other taxes such as energy tax, income tax or consumption tax. To reduce energy tax would, however, mean to offset the effects of carbon tax. To reduce income or consumption tax would not have such a defect.

   With regard to carbon trading, the problems are high transaction costs and difficulty in initial allocation. If carbon emission permits are to be held by each energy consumer, transaction costs would be very high and initial allocation would be very difficult. One way to solve this problem is to allocate permits upstream, i.e., to allocate permits to the importers of fuels, namely, oil companies, gas companies, electricity companies, etc.. However, this would cause another problem. In addition to the problem of how to allocate permits to those companies initially, it would cause the distributive problem between those companies and consumers. Responding to the limitation of the total amount of carbon permits, the consumption of fossil fuels will decrease, but this will happen through rise in fuel prices. This means importing companies profit for the losses at the consumers' side. One means to resolve this problem would be to allocate permits by auction instead of grandfathering, and to redistribute the revenue from the auction to consumers.

If these means are adopted, the political feasibility, the most intractable problem with carbon tax and carbon trading, would be raised. With regard to efficiency, the two measures are equivalent. With regard to certainty, carbon trading is superior to carbon tax.

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