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Article

Evolution and evaluation of air pollution control policy in Taiwan

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Abstract Over the last 5 years the air quality in Taiwan's cities has gradually improved. Part of the credit for the improvement has been given to the air emission fee program that was first implemented in 1995. Before then, the traditional command-and-control program and tax-allowance subsidy were the two major instruments used for air pollution control. The Air Pollution Control Act was revised in early 1999. Among its many new features, the most important one was a new control program, the cap-and-trade program. Moving from a fee to a cap-and-trade program has been a unique Taiwan experience. The purpose of this article is to compare the four existing programs (i.e., command-and-control, tax-allowance subsidy, emission fee, cap-and-trade) in terms of both economic and public choice theories.

Key words Air pollution control policy · Command-and-control · Tax-allowance subsidy · Emission fee · Cap-and-trade

1 Introduction

Economic policy has played an important role in the course of environmental degradation in Taiwan. At the same time, environmental quality has played an important role in the course of environmental and economic policy decision-making. The economic policies the administration has adopted since the 1960s may be regarded as a series of economic liberalization policies, which have step by step corrected the previous biased policy mix that was established a few years after Taiwan's retrocession from Japan in 1945.[1] These policies released the

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Parts of this article are drawn from an earlier paper by one of the authors (Shaw 1998).

[1] During the 1950s, to counter the huge trade deficit, Taiwan pursued its first phase of import-substitution, which included a highly interventionist and protective policy mix. Although the policy mix was able to solve some problems successfully by the end of the decade, as in other developing countries, it was highly protective and inefficient. Fortunately, around 1960, to relieve the pressure arising from the saturated domestic market, reduced U.S. aid, and the huge trade deficit, the administration adopted a series of policy changes that created an environment beneficial to exporting highly labor-intensive products in exchange for highly capital-intensive products. Ma (1990) has labeled the period encompassing these policy changes the First Phase

energy that had been suppressed by the earlier, more restrictive policies and that had accumulated within the economy (Ma 1990). As a result of this released energy, the economy's comparative advantage was after every policy reorientation found to lie in production factors, such as labor, natural resources, energy, capital, and technology. The economy has subsequently performed extraordinarily over the last four decades. The quality of the environment as a factor of production, however, was virtually ignored before the 1970s. Table 1 presents major policy reorientations and some key indicators of economic performance and environmental loads during the past five decades.

During the 1950s and 1960s, when per capita income and industrial production levels were still low, environmental resources were considered "free goods" in the sense that there was an ample supply of them to meet the relatively light demands of the economy. As such, the pressure placed on the environment by polluting activities and the economic values placed on natural resources were not deemed large enough to warrant the development of new programs to internalize externalities. Consequently, environmental considerations were ignored, and environmental protection policies were not developed during this period.

During the 1970s, public environmental awareness surfaced as a result of increasing environmental damage and higher personal incomes, although somewhat prematurely. Because of the economic development that had occurred during the preceding 20 years, as well as the growth of heavy and petrochemical industries during the 1970s, environmental loads in Taiwan increased rapidly (see Table 1 for indicators of environmental loads). These loads contributed greatly to the increased value placed on environmental quality and natural resources. The increase in personal income also led to an increase in the demand for a better-quality environment. We can therefore conjecture that the benefits arising from the internalization of externalities became equal to the respective costs at around this time, and consideration began to be given to environmental factors in the policy-making process.

Several important environmental laws were passed during the 1970s, such as the Pesticide Act (1972), the Drinking Water Act (1974), the Water Pollution Control Act (1974), the Solid Waste Management Act (1974) and the Air Pollution Control Act (1975). However, the laws were subsequently poorly enforced as the result of a lack of administrative regulations and procedures as well as a shortage of funds and personnel, as public environmental awareness had still not sufficiently developed to equate environmental considerations with economic

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of Economic Liberalization. At the beginning of the 1970s, the administration adopted a policy of developing the heavy and petrochemical industries and also upgraded the social and economic infrastructure. Consequently, during the late 1970s Taiwan's reliance on imports of intermediate products and capital equipment decreased, a phenomenon referred to as secondary import-substitution, which led to an overall reduction in imports that affected the trading structure of the 1980s and gave rise to the ensuing trade imbalances. Under strong pressure from the United States, Taiwan's most important trading partner, to correct these imbalances, the administration finally implemented the long-awaited liberalization measures during the 1980s. This has resulted in a reduced trade surplus and a great change in the industrial structure.

Table 1. Key indicators of economic performance and environmental load

Indicator	1950s[c]	1960s[c]	1970s[c]	1980s[c]	1990s[c]
Economic performance					
Economic policies	Import-substitution	First phase of economic liberalization: export-promotion	Secondary import-substitution: development of heavy and petrochemical industries	Second phase of economic liberalization: automation and outward investment	Same as the 1980s
Average annual growth rate of real GNP for each decade (%)	7.7	9.4	10.0	8.3	6.3
Per capita GNP (US$)	131	345	1920	7512	13248
Environmental policies	None	None	CAC and tax-allowance subsidy with little enforcement	CAC and tax-allowance subsidy with stronger enforcement	CAC, tax-allowance subsidy, and economic incentives
Environmental loads					
Population density (person/km^2)	290.07	398.62	485.50	558.54	611.95
Energy consumption density (1000 kl oil equivalent/km^2)	0.148	0.380	0.916	1.46	2.36
Motor vehicles density[a] (units/km^2)	1.6	27	150	287	452
Factory density (units/km^2)	0.57	0.56	1.67	2.61	2.80
Cattle density (heads/km^2)	12	7	4	5	5
Hog density (heads/km^2)	86	86	134	216	201
Chicken density (heads/km^2)	220	464	1219	2138	3374
Chemical fertilizer density (kg/km^2)	13875	24725	34875	32723	32734
Solid waste[b] (kg/person-day)	0.47	0.53	0.63	0.90	1.08

CAC, command-and-control

Data sources: *Taiwan Statistical Data Book* (Council for Economic Planning and Development); *Yearbook of Environmental Protection Statistics* (Environmental Protection Administration); *Agricultural Statistics Yearbook* (Council of Agriculture)

[a] Includes four-wheel vehicles and motorcycles

[b] The 1959 and 1969 figures are predicted by an estimated regression function using 1979–1988 data

[c] The figures in each decade are the figures for 1959, 1969, 1979, 1989, and 1999, respectively

ones in the policy-making process. Consequently, the quality of the environment continued to deteriorate.

During the early 1980s, owing to the more rapid deterioration in the quality of the environment, the costs borne by society as a whole probably exceeded the benefits of economic development. As a result, citizen-led antipollution groups emerged to put pressure on the administration, which caused the administration to change its environmental policies and increase the amounts of funds and people assigned to monitor and enforce the various environmental protection laws and regulations. During this period there was a sharp increase in public environmental awareness, as evidenced by the large number of "not in my back yard" (NIMBY) protests staged by various citizens' groups all over the island. Several siting proposals were either killed outright or delayed, and some existing plants also had to be closed. The administration, finally responding to public pressure, established the Environmental Protection Administration (EPA) at Cabinet level in 1987. It also filled in some of the holes in the existing laws, increased the amount of funds allotted to environmental protection, and allowed hiring of more personnel.

Following its establishment, the EPA applied the traditional command-and-control (CAC) approach to control air pollution with a heavy hand. Pollution control policies also went through substantial reforms in view of the arguments leveled against existing approaches. The tax-allowance subsidies, administered by the Ministry of Economic Affairs since 1974, were reduced when the three-decade-old Statute for the Encouragement of Investment was replaced with the Statute for Upgrading Industries in 1990. Following that, the Air Pollution Control Act was revised in 1992 to adopt the air pollution emission fee, the first environment-friendly economic incentive program, to control air pollution; it was implemented in 1995. These reforms emerged because of the considerable deterioration in the quality of the environment, increased environmental awareness, a growing desire for environmental quality, and demands to improve environmental quality in a cost-effective manner.

Finally, the air quality in Taiwan's cities started to improve gradually during the 1990s. This can be seen from Figs. 1 and 2, which show the 1989–2000 air quality indicators for Taipei and Kaohsiung, the two most populated and polluted cities in Taiwan. However, because the improvements have not taken place sufficiently and quickly, and it is highly likely that the air quality may in fact worsen owing to the ever-increasing population, production, and consequently heavier environmental loads, the EPA has proposed adoption of a quantity-based control program, the cap-and-trade (CAT) program, as a last resort for pollution control.[2] The Legislative Yuan (Parliament) revised the Air Pollution Control Act accordingly in early 1999.

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[2] The EPA has stated its goal of air quality improvement as less than 3% of monitoring days that Pollutant Standards Index (PSI) > 100 by 2001 in the National Environmental Protection Plan (Environmental Protection Administration 1998). Figs. 1 and 2 show that the air quality has improved following the establishment of EPA. However, the percentage that PSI > 100 in 2000 is 5.18% (*Yearbook of Environmental Protection Statistics*, 2001). We could expect that the goal of 2001 would not be met if no further control measures were adopted.

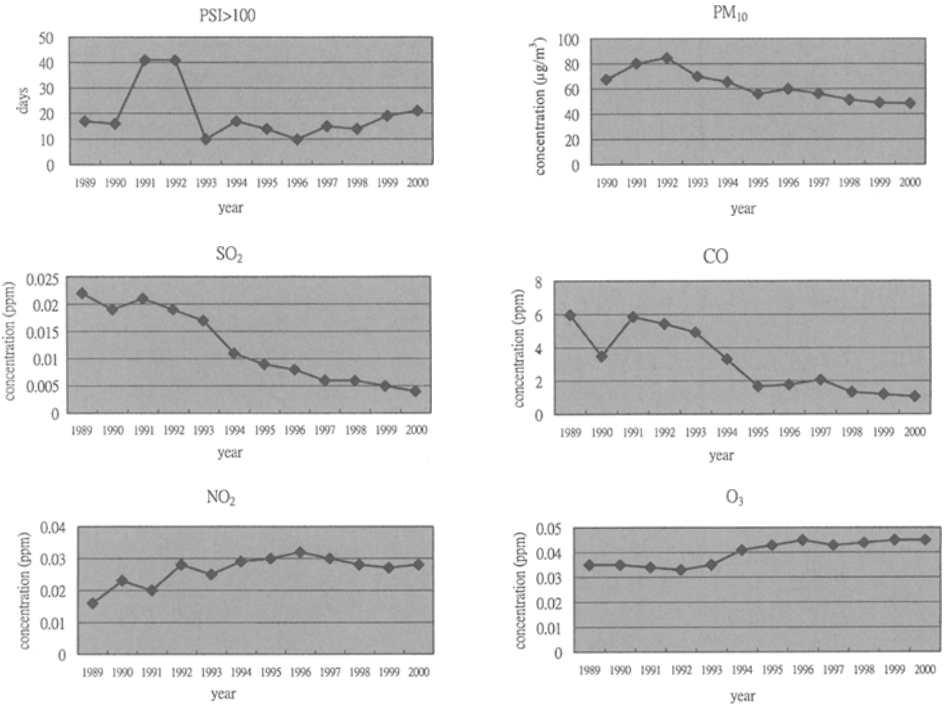

Fig. 1. Average annual concentration of air pollutants in Taipei. The graph of PSI > 100 reports the data from the Sungshan air quality monitoring station in Taipei. PSI, Pollutant Standards Index. Data sources: *Yearbook of Environmental Protection Statistics* (Environmental Protection Administration)

In this paper we assess the four policy instruments adopted for air pollution control in Taiwan (i.e., command-and-control, tax-allowance subsidies, emission fees, cap-and-trade approaches) from the perspectives of both theory and practice. We first compare the four programs theoretically to note the different impacts of the four instruments per se on the environment and the economy to clarify the rationale for applying economic-incentive instruments in Taiwan. Next we examine the performance and effectiveness of the four instruments in practice. Many confounding factors can affect and change the theoretically expected outcomes of policy instruments, and these factors are analyzed from the economic and political economic points of view. We finally draw some conclusions and discuss policy implications.

2 Theoretical comparison of control programs

Although the comparison of control programs has been studied in detail and has become a regular part of environmental economics textbooks [e.g., Downing (1984, Chapter 9); Baumol and Oates (1988, Chapter 14)], our analysis adds two new features and makes some contributions to the literature. First, two more

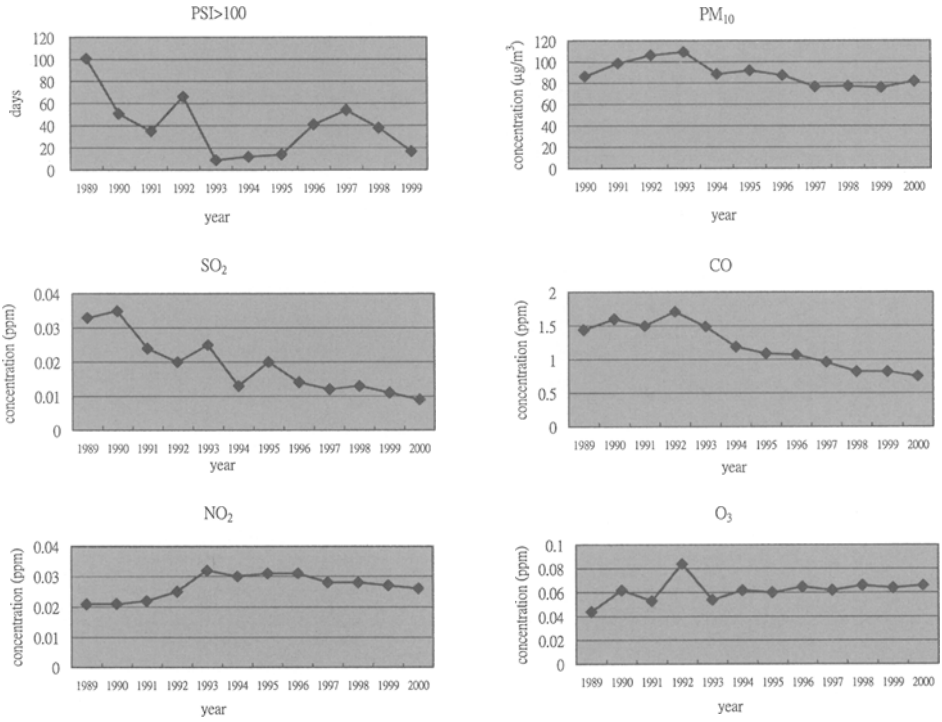

Fig. 2. Average annual concentration of air pollutants in Kaohsiung. The graph of PSI > 100 reports the data from the Sanmin air quality monitoring station in Kaohsiung. Data sources: *Yearbook of Environmental Protection Statistics* (Environmental Protection Administration)

programs (i.e., the tax-allowance subsidy program and the cap-and-trade program) are included in our analysis. In Taiwan instead of the emission reduction subsidy program that usually appears in textbooks, the major subsidy program takes the form of a tax allowance for investment in pollution-control equipment, in which case the government absorbs a certain percentage of the pollution-control cost.[3] In the case of the cap-and-trade program, two common allocation methods, grandfathering and auction, are analyzed here. Second, the effects on innovation are analyzed more thoroughly. Revenue from the sale of patents is counted as part of the incentive to innovate in addition to the cost savings from innovation.

There are certain assumptions to be noted at the outset. First, we consider a perfectly competitive industry comprising many small firms, in which perfect

[3] The tax-allowance subsidy might only be effective if combined with a program of enforcement, such as a well-performing command-and-control program as assumed here. Kneese and Bower (1968) argued that such subsidies can never by themselves make abatement investment profitable.

information is freely available to all firms as well as to the pollution control authority. Second, as a benchmark for comparison, we assume that the regulator has the incentive to maximize social welfare and implement the optimal settings of each control program. Third, we assume that all four programs work as expected in this section. This means that there are no confounding factors (e.g., transaction costs, uncertainty, strategic behavior) to disturb successful implementation of the programs. The programs are enforced fully. Fourth, the revenue source for the tax-allowance subsidy or the expenditure of the fee or auction revenue would not affect any decision making by an individual firm.

A four-panel figure (Fig. 3) is used for analyzing the effects of commodity markets and pollution emissions simultaneously. The upper two panels are related to the commodity market: Panel A is a firm-level diagram, and panel B is an industry-level one. The lower two panels are related to pollution emissions, where $MERC_i$ in panel C is the marginal emission reduction cost function for individual firms; and the $MERC_T$ and MD curves in panel D represent the total MERC function and the marginal total damage for the area, respectively. When there are no pollution control programs, individual firms do not control any pollution and produce output q_0 and emit e_0. Price and output in the market for final goods are P_0 and Q_0, respectively, and total pollution is E_0.

At the beginning, based on the social optimum condition of pollution control (i.e., $MERC_T = MD$ in Fig. 3D), the EPA makes decisions regarding the emission standard (e_1 for each firm), the emission fee (f_1), and the total number of permits supplied (the cap, or E_1) under various programs. The effects of the four governmental control programs on the costs of control and residual payments, short-run emission levels and outputs, the market for final goods, long-run emission levels, and the effects on innovation are analyzed as follows.

2.1 Costs of control and residual payments

When the CAC approach with an e_1 emission standard is applied, the firm incurs the pollution control cost of Be_0e_1 in Fig. 3C. This cost is lower under the tax-allowance subsidy program because the government absorbs a portion of the cost of abatement equipment. An emission fee of f_1, with an equivalent emission reduction effect, generates a financial burden of $OABe_0$ (i.e., the sum of pollution control expenditure Be_0e_1 and emission fee payments $OABe_1$. Under the CAT program, when the EPA freely grandfathers the cap (E_1, Fig. 3D) among existing firms and each firm is assumed to be allocated its efficient amount of emission permits (e_1, Fig. 3C), individual firms therefore must pay only control costs of Be_0e_1, the same financial burden as that under the CAC program.[4] On the other

[4] Of course, if each existing firm's free initial emission permits were different from its efficient emission level e_1 under grandfathering, each firm would still need to control pollution up to e_1, and some firms would need to buy more permits from others; f_1 is the equilibrium price of the permits. Thus, the aggregate financial burden of all existing firms would still be the same as that under the CAC approach.

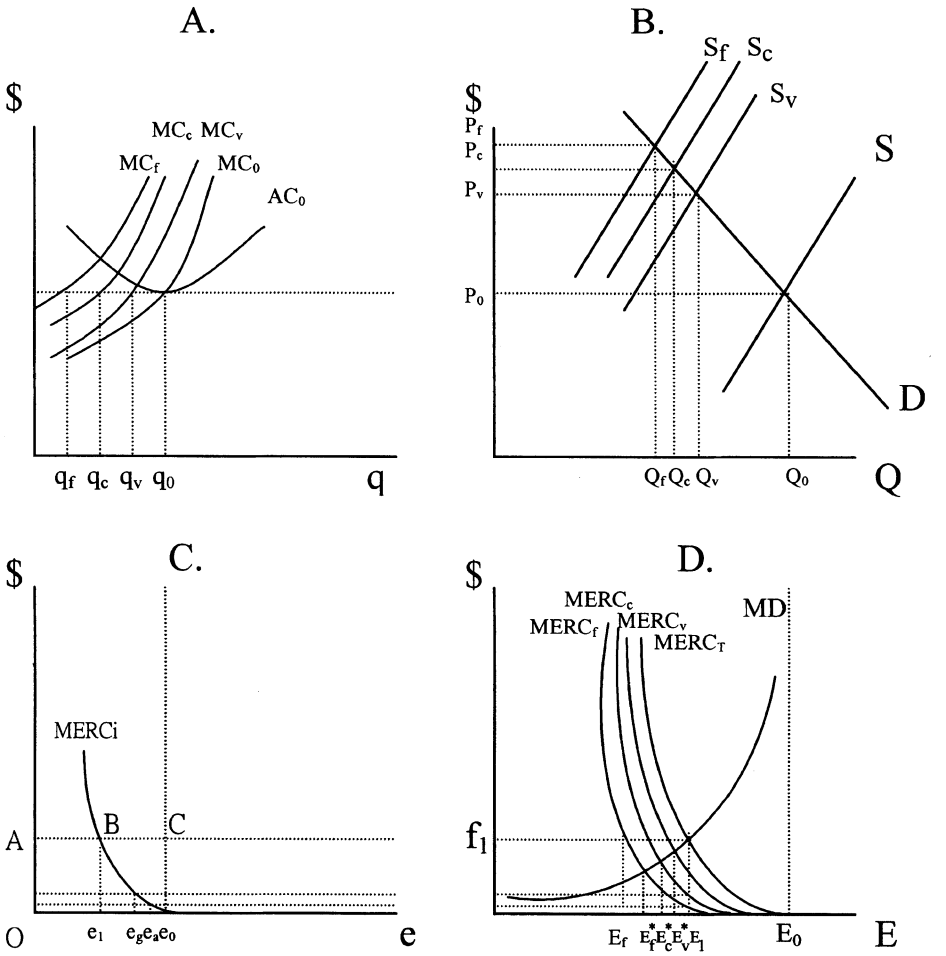

Fig. 3. Firm and market adjustments and pollution emission effects under alternative pollution control systems. Subscript i represents individual firms; subscript v the tax-allowance subsidy; subscript c CAC or grandfathering; subscript f emission fees or auction; subscript T, total; MERC, marginal emission reduction cost; MD, marginal total damage

hand, if the auction method is applied, the financial burden of firms is equal to that under the emission fee approach, as the expenditure related to purchasing emission permits is equal to the emission fee expenditure.

By comparing the four programs with the no-control case, we find that costs to firms increase the most under the emission fees program and the CAT with auction program and the least under the tax-allowance subsidy program.

2.2 Short-run emission level and outputs

Pollution control programs increase the costs of final goods and cause the firm's marginal cost (MC) curve to shift to MC_v (v denotes the tax-allowance subsidy), MC_c (c denotes CAC or grandfathering), and MC_f (f denotes emission fees or auction), respectively. The comparative effects on the firm's output of final goods can be seen in Fig. 3A.

When faced with every control program, profit-maximizing firms would react by reducing outputs or implementing abatement programs to reach the same emission level of e_1. Because firms' control costs are the highest under fees or auction, it is therefore less expensive to meet the target by reducing output more (to q_f). Short-run final goods' outputs are reduced from q_0 to q_v, q_c, and q_f, respectively, under each program; and short-run losses (the most for emission fees or auction programs and the least for subsidy programs) also occur.

2.3 Market for final goods

When all or a significant number of firms operating in a market are affected by the pollution control policy, the market supply curve shifts, generating changes in price and quantity produced. Because the market supply curve is the sum of individual firms' MC curves, it shifts in the same way as do the MC curves. These shifts and their effects on the market quantity and price are presented in Fig. 3B. Quantity adjustments for the market follow the same pattern as for individual firms. Price increases the most in the case of an emission fee (or auction) and the least in the case of a tax-allowance subsidy.

Furthermore, price changes in the long run affect the number of firms remaining in the industry. Firms with the highest control costs drop out of the industry. Let N denote the number of remaining firms. Its rank is $N_f < N_c < N_v$ under different programs.

2.4 Long-run emission levels

In the long run, firms can adjust their production processes and abatement technologies given the control policies. They may also exit the market freely. Because the $MERC_T$ curve is the sum of the $MERC_i$ for each firm, $MERC_T$ shifts slightly downward to the left when any firm exits.[5] In Fig. 3D, the original efficient level of total emissions is E_1. After firms make adjustments under each program, the losses of some firms under different programs shift $MERC_T$ to $MERC_v$, $MERC_c$, and $MERC_f$, respectively. Thus, the efficient levels of total emissions under each program now become E_v^*, E_c^*, and E_f^*, respectively. To meet these new targets in relation to efficient emission levels, the government should relax emission standards, reduce emission fees, or issue fewer permits.

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[5] The efficient output for each firm also differs as a result of market price effects. This can shift MERC. We ignore these effects, however, because they complicate the analysis unduly.

Because frequent changes in the emission targets would result in large adjustment costs to firms, however, the environmental agency is assumed to take this into consideration and precommit at the outset to a policy of not adjusting any of the programs after implementation. The final individual and total emissions for the initial design of each program would then be as follows.

1. If the emission fee were not adjusted downward, an individual firm remaining in the industry would emit e_1 as usual, and the total emission in the area would be E_f, which would be less than the new efficient level E_f^*. E_f is also less than the original efficient level E_1 because the number of firms is reduced.
2. If the allowed cap on total emissions were not adjusted downward, the price of permits would decrease, as the reduction in the number of firms would cause the aggregate demand for emission permits to decrease. The price of permits decreases more under auction approach than under grandfathering. Lower prices of permits would result in higher individual firms' emission levels e_a and e_g under auction and grandfathering, respectively.
3. If the emission standard were not adjusted, the individual firm would emit e_1 as usual, and the total emission would be smaller than E_c^* and greater than E_f. The total emission should be smaller than E_c^* because E_c^* would be the total emission level if the EPA were to relax its emission standard. Because the EPA does not relax its emission standard, with the same number of firms the total emission should be less than E_c^*. On the other hand, the total emission should be greater than E_f because the number of firms under CAC is greater than that under an emission fee program and a firm emits the same e_1 level under both programs.
4. If the tax-allowance subsidy rate were not adjusted, with the same emission standard, each firm would emit e_1, and the total emission would be higher than that under CAC because the number of firms is greater under the tax-allowance subsidy program than under CAC.

We conclude that in the long run the individual emission level e_a (under auction) $> e_g$ (under grandfathering) $> e_1$ (under an emission fee, CAC, or a tax-allowance subsidy), and the total emission E_1 (under auction or grandfathering) $> E_v$ (under a tax-allowance subsidy) $> E_c$ (under CAC) $> E_f$ (under an emission fee) if the environmental agency does not adjust its optimally designed initial programs.

2.5 Effects on innovation

An innovation may take several forms. Here we view an innovation as a change that could reduce a firm's MERC to MERC′ in Fig. 4. Two questions on innovation are asked: (1) Under which program are firms the most willing to adopt a new pollution control technique invented by others? (2) Under which program are there the most incentives for firms to innovate? The first question is related to the savings in pollution control. On the other hand, incentives to innovate are

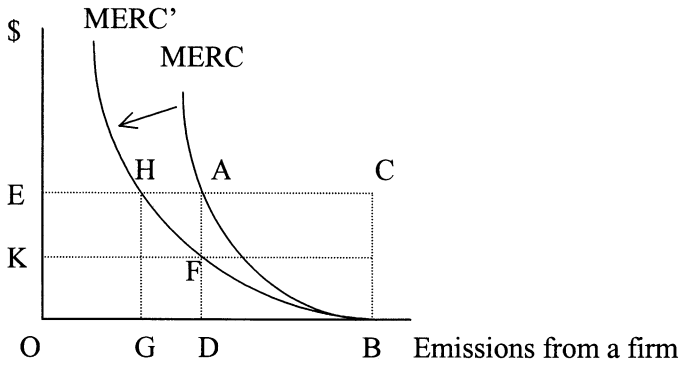

Fig. 4. Savings from pollution control innovation. E, initial emission fee or permit price; D, emission standard. See text for further explanations

related to the innovation profit under patent protection in addition to the savings in pollution control.

Let us first examine the question of adopting innovation. For the sake of comparison, we assume that E in Fig. 4 is the initial permit price or emission fee, and D is the emission standard. Under the CAC system, should an innovation be available, the firm would save pollution control costs equal to the area ABF, and would retain the same level of emissions (OD). Under a tax-allowance subsidy system, because the agency would absorb some proportion of the abatement costs, the cost savings from innovation would therefore be less than those under the CAC.

Under the emission fee system, adopting the same innovation results in a saving of the area ABH, and the firm reduces its emission level to G. Under the cap-and-trade system,[6] the savings in the beginning is the area ABH, too. However, the savings might become smaller and smaller as more and more firms adopt the new innovation because decreasing demand for emission permits drives down the price of permits. In comparison, we find that firms under the fees approach are most likely to adopt an innovation because of the greatest savings to be obtained.

Let us examine the next question of innovation incentives. In addition to the savings, we must also consider innovation profits. Hsu (1998) has proved that the demand curve for innovations is flat under each of the emission fee, CAC, and tax-allowance subsidy programs. However, the demand curve for innovations negatively slopes under the CAT program.[7] The main rationale for the differences in slopes is that, under the former three programs, firms' willingness to pay

[6] Assuming no exit and entry here for simplicity, the effects on innovation are the same under grandfathering and auction.

[7] Assume that there are N firms in an industry and each firm needs only one unit of the new device.

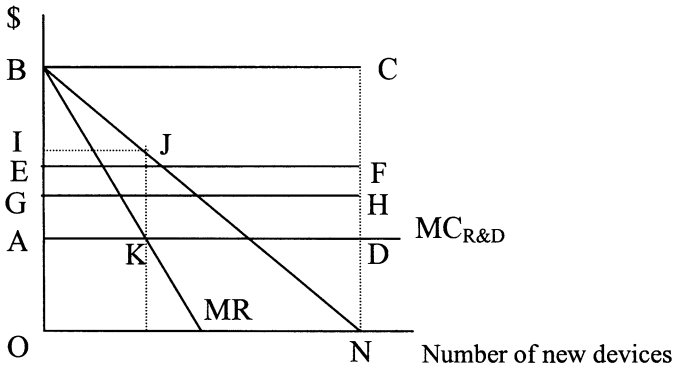

Fig. 5. Profits from pollution control innovation. $MC_{R\&D}$, marginal cost of innovation. See text for further explanations

(WTP) for the innovation is simply the savings from the innovation. No matter how many other firms adopt the innovation, however, the savings from innovation remain constant under each program. The demand curve faced by the innovator is therefore flat and is highest under the fees program and lowest under the tax-allowance subsidy program. In Figure 5 they are respectively denoted as BC for fees, EF for CAC, and GH for tax-allowance subsidy. On the other hand, under the CAT program, as the number of firms adopting innovation increases, the demand for permits decreases, and the price of permits and savings decrease accordingly. The WTP for the innovation therefore decreases, and the slope of the demand curve is negative, as depicted by BN in Fig. 5.

With strict patent protection, the innovator is a monopolist of his innovation. Assuming that the marginal cost of innovation ($MC_{R\&D}$) is constant, as shown by AD in Fig. 5, the innovation profits are therefore area ABCD for fees, AEFD for CAC, AGHD for tax-allowance subsidy, and AIJK for CAT, respectively. It is quite certain that the profit is the highest under the fees program, but the order of the magnitude of profits under the other three programs is not clear.

By adding the innovation profits and the savings together, it is found that the innovation incentives are the highest under the fees program. It is not clear, however, whether CAT could create greater innovation incentives than the CAC and tax-allowance subsidy programs.[8]

[8] The literature on environmental regulation and innovation [e.g., Kneese and Schultze (1975), Marin (1978), Mills and White (1978), Russell (1979), Downing and White (1986), Milliman and Prince (1989), and Jung et al. (1996)] has concluded that CAT and fees encourage more innovation than CAC. Hsu (1998), however, proved that CAT provides fewer incentives for innovation than the other approaches. Moreover, the fees system, loosely speaking, encourages more innovation than CAT [e.g. Downing and White (1986), Hsu (1998), Requate (1998), Denicolo (1999)]. Milliman and Prince (1989) and Jung et al. (1996), however, differ.

All of the above analytical results are summarized in Table 2. First, we can easily see that the emission fee program is best because it not only can provide incentives for individual firms to meet a predetermined environmental target cost-effectively with an invisible hand (Baumol and Oates 1988), it can provide the greatest pollution control innovation incentive. Second, CAC is inferior to the fee program, with the tax-allowance subsidy program even more inferior, based on the criteria of cost-effectiveness and innovation incentives. Third, although the CAT program, another economic incentive instrument, is also cost-effective, it has lower innovation incentives than the fees program.

The innovation incentives of the CAT program, however, can be easily raised. First, the allowed cap on total emissions could be gradually adjusted downward (i.e., by ratcheting the issued amount of permits) to make the price of permits not decrease and therefore maintain innovation incentives. Second, firms under the CAT program may have incentives to innovate and reduce their dependence on permits because they would face greater uncertainty regarding whether they can acquire enough permits. This uncertainty would be exacerbated, as population and economic growth would definitely accelerate the control pressure.

In practice, the two inferior programs, the CAC and tax-allowance subsidy programs, were among the first wave of air pollution control instruments used in Taiwan. The two better programs, fees and CAT, have recently and will in the future be used to control air pollution. In the following section, we examine the performance of each of these four programs.

3 Assessment of air pollution control policies in practice

Because of many public choice factors, such as incomplete information, incentive-compatibility, the principal-agent problem, interest groups, enforcement problems, and so on, the real world outcomes of environmental policies are usually not the same as those that would be expected from theoretical analyses. We therefore assess air pollution control policies in Taiwan using both the results of the economic analysis in the last section and the views put forward by public choice theory.

3.1 Pollution control policies prior to the reforms

The CAC program was the first instrument applied to air pollution control. Its adoption has been quite straightforward, and it has tended to resolve externality problems in most economies. In addition to CAC, some financial subsidy and technical assistance programs have been used because the authorities intended to reduce the cost pressure of firms engaged in pollution abatement.

3.1.1 Command-and-control approach

Two characteristics of the CAC approaches employed in Taiwan can be easily identified: (1) ambient air quality standards are not binding and have not played

Table 2. Summary of effects of alternative pollution control programs

Parameter	Effects, by type of pollution control system				
	Tax-allowance subsidy	CAC	Emission fee	Cap and trade: Grandfathering	Cap and trade: Auction
Emission level of individual sources					
Short run	Same as initially planned	Same as initially planned	Same as initially planned	Same as initially planned	Same as initially planned
Long run	Same as initially planned	Same as initially planned	Same as initially planned	Lower than before control and higher than subsidy	Lower than before control and higher than grandfathering
Control costs of individual sources	Positive loss and lower than Be_0e_1 under CAC	Loss of Be_0e_1 (Fig. 3C)	Loss of $OABe_0$ (Fig. 3C)	Same as CAC	Same as emission fee
Profit	Short-run loss	Short-run loss and greater than for subsidy	Short-run loss and greater than for CAC	Short-run loss and same as CAC	Short-run loss and same as emission fee
Final goods output	Lower than before control	Lower than before control and subsidy	Lower than before control and CAC	Lower than before control and same as CAC	Lower than before control and same as emission fee
Final goods price	Higher than before control	Higher than before control and subsidy	Higher than before control and CAC	Higher than before control and same as CAC	Higher than before control and same as emission fee
No. of firms	Fewer than before control	Fewer than before control and subsidy	Fewer than before control and CAC	Fewer than before control and same as CAC	Fewer than before control and same as emission fee
Total emissions	Lower than originally planned	Lower than originally planned and for subsidy	Lower than originally planned and for CAC	Same as originally planned	Same as originally planned
Incentives for innovation adoption	Higher than no control	Higher than subsidy	Highest	Higher than no control, and equal or lower than emission fee	
Innovation incentives	Higher than no control and lower than CAC	Higher than subsidy and lower than emission fee	Highest	Higher than no control and lower than emission fee	

important roles in decision-making about emission standards; and (2) air pollution emission standards differ depending on the area and industry. Although the differences between areas are quite small, there are substantial differences between industries.[9] These two characteristics are reviewed.

First, because air quality standards and emission standards are the pollution control instruments mandated by law, what we need is a set of standards compatible with economic efficiency. In theory, air quality standards and emission standards should be closely related as the result of a two-stage analytical process (Freeman 1990). At the first stage, a set of air quality standards for each air basin would be established such that in each case the marginal benefits of the standard would just equal the associated marginal cost. The second stage would involve determining the individual emission reduction requirements necessary to meet the quality standard for each air basin at the minimal cost. This process of standard-setting results in differential quality standards and emission requirements across basins and dischargers because of differences in benefits and costs.

This analytical process was not followed by the Air Pollution Control Act (APCA). The objectives of the APCA are ambiguous, and the existing national air quality standards are not binding for determining emission standards. This gives the environmental authority in the central government and local authorities great flexibility when enforcing emission standards. Although this approach can avoid the infamous economic inefficiency of the rigid national target of fishable and swimmable water quality and an ultimate target of zero pollutant discharge as established in the U.S. Federal Water Pollution Control Act of 1972, the flexibility allows the environmental authority in the central government easily to fall into the hands of the Ministry of Economic Affairs (MOEA) and the interest groups of the polluting industries. Emission standards may consequently be set less stringently and the standards enforced only selectively.

On the other hand, in theory, an emission standard should be based on the total quantity of the pollutant in question emitted by a pollution source, as the total emission is the major factor affecting the environment. For more populated areas, there should also be more deductions for emissions, and dischargers with lower marginal costs of control can afford to and should exercise more control.

All of the air emission standards in Taiwan are based on concentrations. This not only does not create enough incentives for dischargers to control emissions but gives them incentives to dilute emissions with air.[10]

Second, air emission standards differ according to the area. The three major local authorities in Taiwan[11] can set their own air emission standards. Although their differences are trivial, at least this is a step in the right direction.

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[9] The Industrial Development Bureau (IDB) has also issued several administrative orders to suspend the production of several highly polluting industries, such as mercury-electrolyzing chlorine and PCP (pentachlorophenol) herbicide.

[10] Only the air pollution emission standards for total suspended particulates (TSPs) are stricter for dischargers with higher air flows.

[11] They are Taipei City, Kaohsiung City, and Taiwan Province.

Air emission standards also differ according to the industry. There are several problems with this kind of standard. First, it is highly information-intensive for the environmental authority to make decisions about standards for so many categories of industry. Second, even in the same industry, firms usually have different marginal costs of control. It is extremely difficult for CAC to be an efficient instrument.

From the viewpoint of public choice, the CAC approaches used in Taiwan are not incentive-compatible and thus are not efficiency-compatible. There are three parties within the playground of this approach: the EPA, the MOEA, and the pollution dischargers. Each has an incentive to behave differently. The EPA, under pressure from the public to clean up the environment within a short period of time, would like to have higher standards. In contrast, the MOEA, under pressure from dischargers to maintain a profitable investment environment, always asks for lenient standards. Dischargers, of course, have no incentives to internalize the external costs and provide true information about their control costs and emissions. Thus, without true information and under heavy pressure from the MOEA and the rent-seeking lobby of the dischargers' groups, the EPA tends to choose standards that are usually not cost-effective or optimal.

When it comes to enforcing the standards, some EPA enforcement officials and dischargers do have the same incentives. They may tend to control less to reduce costs. Bribery and extortion therefore take place. That is, they may transfer payments among themselves instead of controlling emissions to meet the standards. This is a typical principal-agent problem.

3.1.2 Tax-allowance subsidy programs

During the early years, the polluter-pays principle was not commonly recognized, and economic development was always the most important issue in Taiwan. To reduce pressures on firms' costs and maintain their economic competitiveness, subsidies were therefore naturally provided. The subsidy programs included tax allowances and soft loans for enterprises and were administered by the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs under the Statute for the Encouragement of Investment. In addition, the IDB provided technical assistance to enterprises at no or subsidized cost from 1983 onward.

Two characteristics of the subsidy programs employed in Taiwan can be easily identified: (1) All of the tax allowances and soft loans programs are based on inputs related to pollution control, especially machinery and equipment. (2) The same machinery and equipment can be applied to every kind of tax allowance and soft loan. The total subsidy received by pollution control machinery can easily reach 40%–60% of its purchase cost (Cheng 1987).

The rationale behind the tax-allowance subsidy programs is that purchasing machinery and equipment and pollution control are presumably highly correlated. According to several review studies that assessed the tax-allowance subsidy programs, however, it was found that even though the subsidy share was quite high the effects of the programs were not noticeable. Cheng (1987) surveyed

firms and found that fewer than 20% of those firms investing in pollution control equipment made the investment decision mainly because of the tax-allowance subsidy programs. Many heavy polluters had not invested in pollution control and did not plan to invest in it at that time. Lin et al. (1988) found that the ineffectiveness of the programs could be attributed to the following:

1. The system of environmental laws was incomplete.[12] Firms faced a low threat of being penalized.
2. Existing pollution-control instruments were not incentive-compatible.
3. Enforcement of existing environmental laws was inadequate.
4. The 40%–60% of the costs that dischargers still had to pay was higher than the expected penalty arising from doing nothing at that time.
5. Subsidies on pollution control inputs had only indirect effects, as dischargers could install equipment but not operate it, thereby saving on operating costs.
6. Small and medium-sized firms usually did not have the information and expertise to apply for assistance.

Thus, the tax-allowance subsidy programs in Taiwan were ineffective in terms of encouraging more investment in pollution control, as the above theoretical analysis would have expected (the effects on innovation were lowest under the tax-allowance subsidy). Moreover, these tax-allowance subsidy programs would have had detrimental effects on the environment because they made firms that were marginally uneconomical in terms of social benefit and cost criteria profitable and caused delays in structural change and innovation—a disservice to their primary objective.

Furthermore, in contrast to the various public choice behaviors under the CAC approach, all three parties have incentives to enlarge the subsidy programs. Usually dischargers would like to have as large a subsidy as possible. The MOEA would also be willing to keep dischargers happy because its main objective is to maintain a profitable investment environment and high economic growth rates. The EPA, under pressure to generate results within a short time, would not object to giving more subsidies to dischargers. Thus, the combined efforts of the three parties have created generous subsidy programs that show no signs of ending, even though the Ministry of Finance did object to extensions of each subsidy program.

3.2 Evolution of the reform

As noted in the Introduction, the reforms in relation to pollution control policy in general and air pollution in particular during the late 1980s resulted from failure of the CAC and tax-allowance subsidy programs adopted in previous periods, the growing demands by the public for a better environment, and increased pressure on the administration for pollution control. As a result, the EPA

[12] For example, acts such as the Soil and Groundwater Pollution Control Act, the Marine Pollution Control Act, and the Environmental Impact Assessment Act were not enacted until the 1990s.

was established at Cabinet level in 1987.[13] Earlier that same year, a proposal to draft the Environmental Protection Basic Act was introduced by a group of legislators. Later the Administration announced its Policy Statement of Environmental Protection, and its version of the Environmental Protection Basic Law was introduced to the Legislative Yuan the following year.

These three documents are important policy statements of the reforms taking place at that time. They all adopted economic incentive approaches, especially the emission fee system, in addition to traditional regulatory approaches. They differed, however, in their attitude toward subsidies. The subsidy programs were required according to the administration's version of the Basic Law and the Policy Statement, whereas they only had to be provided when necessary according to the legislators' version of the Basic Law.

Reductions in the tax-allowance subsidy and the adoption of economic-incentive instruments have already been adopted in several revised laws. First, with respect to subsidy reductions, the Statute for the Encouragement of Investment was abolished at the end of 1990 and was replaced with the Statute for Upgrading Industries. Though there are virtually no differences between the two laws in terms of subsidy items, a sunset clause was added. It was to graduate the income tax allowance program for purchasing pollution control machinery and equipment, the most important subsidy, at the end of 1995.

However, the sunset year of 1995 was extended to 1999 and extended again to 2009 when the Law underwent subsequent revisions. It is expected that the only opportunity to break this vicious cycle might come as a result of external pressure such as the World Trade Organization's Agreement on Subsidies and Countervailing Measures' requirements. Undoubtedly, the extension of the sunset year is the result of the strong combined efforts of the heavy lobbying industrial interest groups and the common interests of the two parties, the EPA and the MOEA.

Next, with respect to environment-friendly economic-incentive instruments, the Air Pollution Control Act (APCA) was amended to adopt an emission fee program and a bubble program[14] in 1992. The actual implementation of these economic instruments has been slow and turbulent, however. The first one the EPA has implemented is the air pollution emission fee program. Because of

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[13] After its establishment, the EPA applied the traditional CAC with a heavy hand. The stronger enforcement, to some extent, contributed to the improvement of air quality during the early 1990s.

[14] Section 1 of Article 15 of the APCA of 1992 states that dischargers having more than one stationary source emitting the same air pollutant within the same air quality control region may be free from the limitations set by the emission standards if their total emissions of a particular air pollutant are less than emissions under applicable emission standards regulations. Although the article has good intention, the EPA's regulation based on this article adds several unnecessary requirements that make transaction costs high. Consequently, this bubble program is not popular because of its high transaction costs and the uncertainty involved in obtaining EPA approval. According to EPA's record, there was only one firm that applied for approval of its bubble program. The firm applied in 1995, but the application was not approved until 1997. The company gave up the bubble permit in 1998.

many differing opinions concerning the contents of the program, there have been many debates, public hearings, demonstrations, behind-the-scene lobbying activities, and even an interpretation of the APCA handed out by the Grand Justices. We now review the air pollution emission fee program and the controversies surrounding the program.

3.2.1 Air pollution emission fee program

3.2.1.1 Contents of the fee program. The APCA of 1992 provided the EPA with a large amount of freedom in terms of promulgating the regulation of the air pollution emission fee program.[15] There were only two principles to which the regulation had to adhere: (1) The fee had to be based on the type and quantity of air pollutants emitted by the pollution sources.[16] (2) The fee revenue had to be earmarked for financing air pollution control projects.[17] Based on these two principles, the EPA promulgated the Regulation for Collecting the Air Pollution Emission Fee and, at the same time, submitted a special budget in relation to the Air Pollution Prevention Fund to the Legislative Yuan for approval in March 1995. The Regulation then went through several revisions before finally being incorporated into the latest revision of the APCA in 1999.

The highlights of the Regulation include the following.

1. In the beginning, in the case of stationary sources, the EPA collected the fee directly from oil and coal importers and producers based on the energy inputs' sulfur contents and the importers and producers of ozone-depleting substances (ODSs). A stationary source could obtain a proportion of its payment back if it was able to prove that the sulfur content of the energy used had been removed in the same proportion. Thus, the actual fee base for stationary sources was the amount of SOx emitted, even though the literal base was the amount of energy used. The sources had to self-monitor the amount of pollutants emitted and report this information to the control agencies. The control agencies approved the reports based on their own data sources.
2. Since 1998, the EPA has collected the fee from stationary sources based on the amounts of SOx and NOx emitted. The rates vary with the locations of the sources and the rates of emission reductions. The rates are higher for those sources in nonattainment or protected natural areas and lower for those sources that have already reduced their emissions by a large proportion. They are zero for those sources using liquid natural gas (LNG) as an energy source.
3. For mobile sources, the EPA at the beginning collected the fee directly from the users of motor vehicles and then from oil companies later based on the quantities of gasoline or diesel consumed. However, the fee is not charged for those vehicles using liquid petroleum gas (LPG) or unleaded gasoline.

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[15] Section 2 of Article 10 of the APCA of 1992 required the EPA to promulgate the regulation of the air pollution emission fee program after consulting with other ministries.
[16] Section 1 of Article 10 of the APCA of 1992.
[17] Article 14 of the Implementation Rules of the APCA.

4. Construction sites have been added to the list of fee payers since July 1, 1997. The local authorities collect the fee based on the location and duration of a construction project.
5. All of the fee revenue is earmarked for financing air pollution control projects including coverage of the costs of collecting the fees and providing air pollution control services by control agencies; providing free consulting services and technical assistance to firms; subsidizing the users of mobile sources to control air pollution, such as extending cash payments to purchase LPG taxis, compressed natural gas (CNG), high-duty diesel vehicles, and electric motorcycles; and providing coverage of the expenses associated with conducting air pollution control research and development.

3.2.1.2 Evaluating the air pollution emission fee program. After inspecting the effectiveness of the fee program, it was found that the fee itself provided a strong incentive for stationary sources (especially major SOx sources) to reduce the emission of SOx by a substantial amount.[18] However, the incentive effect in relation to the users of mobile vehicles to reduce energy usage was small because the fee rates were too low. It was also believed that the rate differentiation between unleaded and leaded gasoline was not particularly effective. This was because the difference (NT$0.2 per liter) accounted for only 1.2% of the prices; and existing measures such as a price difference of NT$1 per liter between leaded and unleaded gasoline and emission standards for motor vehicles requiring catalytic converters had already resulted in a significant reduction in the use of leaded gasoline since 1990.

Upon closer examination, the two most important issues related to the fee program may be identified as follows.

1. *Earmarking the revenue for air pollution control.* There is a trade-off between the environmental and fiscal (revenue-raising) objectives of the air pollution emission fee with earmarked revenue. From an environmental point of view, a higher fee rate is required to bring about a large decrease in the amount of the pollutants emitted. From a fiscal point of view, however, because the air pollution expenses of the control agencies are much lower than the amount that can be raised by such a broad-based fee, the rates cannot be set high enough to give economic incentive to sources to reduce the air pollution emitted. However, these low rates are not consistent with the pronounced objective of environmental effectiveness and the polluter-pays principle.

In addition to the problem of environmental ineffectiveness, earmarking the revenue for air pollution control has resulted in an inefficient allocation of

[18] Lee (2000) empirically estimated a marginal cost function of abating SOx using a 1996 data set of 206 stationary sources in Taiwan. It is found that 40% of them have marginal abatement costs lower than the highest emission fee rate of NT$12/kg SOx. Although the emission fee program may provide SOx abatement incentives for only 40% of the stationary sources, the total amount abated is still substantial, as those lower marginal cost sources are mostly major sources.

resources and governmental budget within the EPA and between ministries. For example, the subsidy for taxi drivers to purchase LPG taxis cannot survive the test of efficiency because even without this subsidy the price difference between LPG and gasoline would provide enough incentive for taxi drivers to switch to the use of LPG vehicles.

Because the revenue has been more than enough in the beginning, many programs unrelated to or only weakly related to air pollution control have been included in the budget of the Air Pollution Prevention Fund, such as those concerned with building urban parks and examining school children's health status. Such spending has been viewed by environmental groups, consumer groups, the public, and legislators as a kind of discretionary spending by the EPA. Without these groups' support, the EPA's budgets and consequently the fee rates have been cut by the Legislative Yuan to a point of environmental ineffectiveness since 1995.

The requirement whereby the revenue must be earmarked for air pollution control also results in loss of the possible benefits of "double dividends." If the government were able to use the fee revenue to lower other distortionary taxes, not only would environmental targets be achieved but the social cost of distortionary taxes would be lower.

2. *Simple laws mandated by the Legislative Yuan and detailed regulations promulgated by the EPA*. There is also a trade-off between the level of freedom the EPA can enjoy and the extent of the pressure the EPA has to endure. At first glance, the EPA appears to enjoy a high degree of freedom resulting from the promulgation on the regulation given to it by the Legislative Yuan. The EPA has actually been hurt by the freedom, however, because it cannot share the political pressure surrounding its decisions with the Legislative Yuan.

Indeed, only 2 months after the first draft of the Regulation for Collecting the Air Pollution Emission Fee was presented by the EPA at a public hearing in January 1994, it was quickly recalled because of strong resistance and several demonstrations staged by consumer groups and taxi drivers. After several public hearings, consultations, and negotiations, the EPA finally formally promulgated the Regulation; and a special budget in relation to the Air Pollution Prevention Fund was laid before the Legislative Yuan for approval in March 1995. However, the environmental and consumer groups were still not satisfied with the Regulation and the budget. Their lobbying activities were so successful that the Legislative Yuan cut one-third of the budget, and a group of 67 legislators subsequently asked the Court of Grand Justices to review the Regulation in June 1995. Another one-third of the budget for the Fund for fiscal year 1996 was then cut.

The major argument against the Regulation is that the bases of the fee are not consistent with the type-and-quantity principle specified in the APCA. The opponents argued that while the APCA specifies clearly that the agencies should collect the fee based on the type and quantity of air pollutants, the bases of the fee during the first 2 years are in large part actually the quantities of different kinds of energy input used by mobile or stationary sources, apart from the ODSs,

during the first year. The EPA chose to use these quantities of energy as the fee bases simply because this approach could be easily implemented and the cost of collection was deemed to be lower.

Another major argument against the budget is that the uses of the revenue are not consistent with the principle of earmarking the revenue for financing air pollution control projects. The opponents believed that many uses were privately or politically motivated.

The Court of Grand Justices handed out their interpretation in May 1997. The interpretation generally supported the Regulation. However, it also asked that the law be revised to ensure that those controversial parts of the Regulation, such as the bases of the fee and the usage of the revenue, be specified clearly. This interpretation facilitated revision of the APCA by the Legislative Yuan in 1999.

3.2.2 From fees to the cap-and-trade program

In addition to clearer specification of the emission fee program in the APCA of 1999, the major new feature of this version is the cap-and-trade (CAT) program.[19] This sequence of implementing the pricing program first and the quantity program later makes Taiwan's experience a unique one in the world.

The emission fee program is much appreciated by many economists, such as Baumol and Oates (1988) and Cropper and Oates (1992). It is concluded that where fees are feasible they represent an attractive source of revenues for the public sector. They correct economic choices, internalize the externalities, and involve savings in certain transaction costs relative to the CAT program. Moreover, according to Weitzman (1974), an emission fee, as a policy instrument, is preferable to a risk-neutral regulator whose objective is welfare maximization if the marginal control cost curve is steeper than the marginal benefits curve. Air pollution is a good example of the pollution whose marginal benefits curve is relatively flat.[20] Thus, there are many reasons for the EPA to adopt the fee program to control air pollution.

However, in addition to the fee program, the APCA of 1999 adopted a new program, the CAT program, to control pollution. There are several good reasons for this. First, rapid population and economic growth may result in ever-increasing total emissions even though individual emissions are lowered under existing control programs. Second, the fees cannot be set sufficiently high to give enough economic incentives to dischargers to reduce emissions due to the

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[19] Basically, firms will be simultaneously regulated by the three programs (emission standards, fees, cap-and-trade) according to the APCA of 1999. The emission standards will be more lenient and the fees lower in the air basin implementing the CAT program, however.

[20] In general, air pollution does not cause obvious, instant damage like hazardous wastes. According to Shaw et al. (1996), the estimated elasticities of PM_{10}, SO_2 and ozone in Taiwan range from 0.02 to 0.27. For example, the elasticity at a mean PM_{10} of $98.98 \mu g/m^3$ is 0.09, implying a 0.09% increase in the probability of catching an acute respiratory disease being associated with a 1% increase in PM_{10} concentration.

political pressure of interest groups.[21] Third, although cost-effective, with the fee program one is faced with more uncertainty when controlling the emissions of air pollution. Fourth, the CAT program is the only candidate that has been studied extensively in Taiwan, and it has two successful examples of air pollution control: the Acid Rain Program and the Regional Clean Air Incentives Market (RECLAIM) in the United States (Tietenberg et al. 1999). The CAT program is therefore regarded as a last resort for the EPA to control pollution with a higher degree of certainty and, at the same time, cost-effectively.

The final CAT program adopted by the legislature is a credit trading system that allows emission reductions of existing dischargers above and beyond a required baseline to be certified as tradable credits. The new or expanding dischargers are required to offset all emission increases by acquiring credits from existing dischargers such that a cap on aggregate emissions can be maintained within an area. In general, credit trading systems have not performed well compared with allowance trading systems because of the higher transaction costs and greater uncertainty inherent in credit trading (Tietenberg et al. 1999). The allowance trading system is the CAT program we discussed in Section 2.

The choice of credit trading instead of allowance trading is a compromise among interest groups. During the discussion and public hearings of the new CAT program, the dischargers are skeptical of the unfamiliar new program and prefer to extend the existing bubble program, which allows emission trading within a given plant to a larger bubble over several plants within a company or even a larger area. A bubble program over a larger area (e.g., an air basin) is actually a CAT program, however. The MOEA accepted the program because it could reduce abatement costs through permit trading. With respect to environmental groups, they basically supported the program because it can achieve more stringent environmental goals with higher certainty. However, some people strongly opposed the trading part of the program based on their environmentalists' ideology that the environment cannot be traded. Thus, the legislature finally adopted the credit trading system, which is more conservative and cumbersome regarding emission trading.[22]

This sequence of implementing the pricing program first and the quantity program later provides the following two advantages in relation to implementation of the CAT program. First, the fee program provides the government with valuable information about firms' emissions. Under the fee program, firms have incentives to suggest that their marginal emission reduction cost (MERC) functions are lower than they actually are, which leads the agency to set a lower fee.

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[21] The fees cannot be set sufficiently high, as they are also forced down by interest groups in Taiwan, not to mention gradually raising the emission fees. Baumol and Oates (1988) showed that one disadvantage of fees is that their adjustment is costly and unpopular for both the administration and the polluters.

[22] A discussion of revising the law to move from credit trading to allowance trading is underway when the EPA designs its first implementation program for the most polluted Kaohsiung-Pintung air basin.

In addition, firms report a smaller amount of emissions to reduce their financial burden with the possibility that monitoring systems do not function well. Therefore, firms' reported emissions are not higher than their actual emissions under the fee program. On the other hand, firms have higher incentives to provide the government with exaggerated MERCs to obtain more initial allocation of emissions if the agency adopts the CAT program with grandfathering. Thus, the EPA could benefit from the reported information regarding emissions and MERCs under the fee program to avoid misallocating higher initial emissions to firms. By taking advantage of the data obtained from the fee program, the EPA could also estimate the total MERC more accurately to find the right number of emissions to issue and to predict the price of emissions under the proposed CAT program with auction.

Second, it is well known that each of the control programs assumes certain environmental property rights. The emission fee program implies that property rights are owned by the recipients; the tax-allowance subsidy program implies that property rights are owned by the dischargers; and the CAC program implies that property rights are shared (Downing 1984). Thus, adoption of the fee program in 1995 has meant that there is a successful transfer of property rights from dischargers to recipients. This makes adoption of the CAT program with auction more appropriate to the dischargers and the public, as this program implies that the property rights are also owned by the recipients. By contrast, adoption of the CAT program with grandfathering is not appropriate because grandfathering implies that the property rights are owned by the existing dischargers.

4 Conclusions

We have assessed the four policy instruments for air pollution control in Taiwan from the perspectives of both theory and practice. In practice, the CAC and the tax-allowance subsidy program do not work well enough. Under the CAC, officials, interest groups, and the public are not incentive-compatible regarding pollution control, and enforcement of environmental laws is not sufficient. The form of a lump-sum subsidy is also unable to change the marginal control incentives of dischargers and makes dischargers that are marginally uneconomical in terms of social benefit and cost criteria become profitable.

From a theoretical point of view, the fee program is an appropriate means of controlling air pollution for many good reasons. However, rapid population and economic growth may result in ever-increasing total emissions even though individual emissions are lowered under existing control programs. In addition, the implementation of emission fees unfortunately meets stronger opposition, as more and more people will be charged. For example, for full implementation of an air pollution emission fee, every driver would have to be charged, which accounts for three-fourths of the population in Taiwan. People do not yet admit that they themselves are also polluters: Polluters are always thought to be firms only.

The earmarking requirement of fees and the political pressure exerted by interest groups have also caused the fees not to have been set high enough to

reach the environmental targets. Collection and use of the revenue, however, has induced many rent-seeking activities from control agencies, interest groups, and politicians. These rent-seeking activities reduce the effectiveness and efficiency of the fee programs. The CAT program might be the EPA's last resort.

The history of environmental policies and environmental quality in Taiwan over the last four decades provides evidence in support of the Demsetz hypothesis. According to Demsetz (1967), property right regimes evolve to internalize environmental externalities when the economic gains from internalization become larger than the costs of internalization (i.e., the transaction costs). Increased internalization results from changes in income levels, economic values, pollution damage, and public pressure; changes from the development of new technology and the opening of new markets; and changes to which old property rights are poorly attuned. We have seen that environmental policies have gradually shifted from no policies at all during the 1950s and 1960s, to the CAC and tax-allowance subsidy approaches of the 1970s, and finally to the emission fee program of the 1990s. These shifts imply a gradual evolution of property right regimes from no property, property owned by dischargers, shared property, and finally the property owned by recipients (i.e., the general public).[23]

Implementing the emission fee program first and the CAT program later is an experience unique to Taiwan. The fee program has the advantages of providing actual emission information and a successful transfer of property rights. This policy reform is more incentive-compatible. For the EPA, environmental groups, and the public, environmental targets may be attained by the cap control; for the dischargers and the economics ministry, CAT is cost-effective relative to CAC. What dischargers now argue is the choice between grandfathering and auction. This choice will not have an impact on the target of environmental quality to be achieved. Environmental auditing is important, however, as dischargers and officials each have incentives to enforce only loosely.

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[23] Because recipients are the owners of the property rights, they can either allocate and trade the property among themselves or authorize their agent (e.g., the government) to do the job depending on the magnitude of the transaction costs. In the meantime, it is less expensive to authorize the government to allocate the property among dischargers and to monitor and enforce the trading.

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