A STUDY ON ENVIRONMENTAL REGULATORY INSTRUMENTS

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THESIS

Submitted to

School of Public Policy and Global Management, KDI

in partial fulfillment of the requirements

for the degree of

MASTER OF ECONOMIC POLICY

1999

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ABSTRACT

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Environmental resources are in general limited and their use in production and consumption activities may lead to their deterioration. When the cost of this deterioration is not adequately taken into account in the price system, the market fails to reflect the scarcity of such resources both at the national and international levels.

Public measures are thus necessary to reduce pollution and to reach a better allocation of resources by ensuring that prices of goods depending on the quality and/or quantity of environmental resources reflect more closely their relative scarcity and that economic agents concerned react accordingly.

Here, I have surveyed previous studies on how economic instruments have the potential to be applied to a wide range of environmental issues. The mein types of traditional and new instruments are reviewed here, and then their combined effects are evaluated, to the extent that existing information permits. Economic instruments constitute one category amongst others of instruments designed to achieve environmental goals.

They can be used as a substitute or as a complement to other policy instruments such as regulations and co-operative agreements with industry. When considering the adoption of economic instruments, it is important to assess the cost and benefits of all policy alternatives.

Economic instruments should be designed to facilitate the integration of environmental policy with other policies, in particular through an appropriate adaptation of various economic sectors' pricing and fiscal structures to conform with environmental goals.

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I INTRODUCTION

The traditional economics playing a leading parts in development of the current industrial society is assessed that it doesn't present the proper resolution of the environmental problems.[1] It developed its theory on condition free market economy. So it didn't discover the proper means resolving the environmental problems which is prescribed as externality problem raising out of the market, which brought about environmental contamination continually.

The traditional economics is trying to solve the environmental problem through the alternative outside the market, 'government's intervention'.[1] The government adopted the policy which regulates the contamination activity or discharge amount by itself as the means of the government's intervention. But the 'price control' restricting indirectly through the change of the price structure(tax, ect) is introduced because there is spreaded the recognition of the 'government's intervention' impeding the efficient distribution of resource. Recently the 'self-control' is positively examined, which has the private institute possessing lots of information related reduction of environmental contamination make an effort voluntarily to improve environment.

In this way, the types of the environmental regulating policy has developed variously. And it is divided into two types which are quantitative control instruments regulating the discharge activity itself and price control making social cost occurring out of the contamination activity inside. Now we will study the effects of each environmental regulating methods, try to find the solution of the policy mix with the proper selecting standards of the policy tools.

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1) Han Gyu-su, Continuable Development - Ecological Economics -, 1997, The University of Seoul City, p113

Ⅱ THE SCOPE AND EFFECT OF ENVIRONMENTAL REGULATORY SYSTEM

The justification for environmental regulation lies in market failures causing environmental externalities which ore only automatically internalised in decision-making in perfectly competitive markets.[2] OECD has grouped the main types of environmental regulation into three categories; command and control instruments, economic instruments and other instruments. Command and control instruments directly regulate behaviour affecting the environment, which include establishing and enforcing emission standards, the approval of the emission company or organization, and prohibition or permission of the specific activity, etc. The economic instruments make the people change their activity through the econonic incentives or disincentives, which includes the all sorts of enission charge system, deposit-refund system, eco-tax system, abatement subsidies, etc. And other instruments include the offer of the information relating to environmental contamination or its reducing method, voluntary establishment of the rule. (Refer to table 2-1). We will examine the emission discharge regulation which important means of command and control instruments, and price control which means economic instruments. Tradable emission permits are regarded as the model that the emission discharge regulation is mixed with the price control. The other instruments are regarded as being divided into emission discharge regulation and price control in its concrete regulation pattern.

2) OECD, Reforming Environmental Regulation in OECD Countries, 1997, OECD, Paris

Table 2-1. Categories and sub-categories of environmental regulatory instruments in OECD countries

Regulatory instruments type	Detail means of the regulation
Command and control instruments	a) The products produced and distributed b) The materials used in production and distribution c) The technologies by which goods and materials are produced d) The residuals which are released into environment e) The locations at which production and other economic activities take place
Economic instruments	a) Charges and taxes b) Grants and subsidies c) Fines etc. for non-compliance d) Market creation mechanisms, such as emission permit trading schemes
Other instruments	a) Environmental planning, environmental impact assessment, life cycle assessment and related extended producer responsibility procedures b) Voluntary individual and association agreements to promote environmental policy objectives through industry covenants, negotiated agreements, self-regulation, codes of conduct and eco-audits c) Information disclosure schemes (Voluntary or compulsory) d) Environmental managament systems and environmental audit procedures to improve cost-effective compliance with agreed environmental quality targets

OECD, Reforming Environmental Regulation in OECD Countries, 1997

2-1. Discharge Regulation

2-1-1. Summary of the Discharge Regulation

The discharge regulation is the policy that the authority regulates directly the discharge activity to keep the environmental contamination in proper level, the most traditional means of the environmental regulation. The representative (typical) policy of the direct regulation is the direct regulation of activities that influences directly or indirectly on discharge of pollutant, such as the establishment of ambient standards & emission standards, the regulation over the installation of the emission & prevention facilities, land-use control, fuel-use control.

The discharge regulatory policy is widely used, as the imposition of penalties is easy and produces results quickly. The first, in command and control instruments, we can make a law despite a few information, and achieve the planned ambient standards through this law.[3] The second, command and control instruments make it clear that dischargers are responsible for environmental contamination through they impose responsibility of observing the emission standards on the discharger.[4] The third, because the way that its regulation method and effect shows is simpler, the possibility that the people accept it politically is high, and the industry, the target of the regulation prefers than others. And it is suggested positively because it is efficient in execution that the authority can judge easily whether the discharger violate or not, and because it has equalization that the same regulation is applied to all dischargers.

But, it is raised ceaselessly that command and control instruments have the problem being inefficient and wasteful in cost. The first, for the

3) M. D. Young, Sustainable Investment and Resource Use, UNESCO, Pathenon, Carnforth, 1992, Chapter 6.

4) B.S. Frey, Pricing and Regulation affect Environmental ethics, Environmental and Resource Economicx 2, 1992, pp 399-414.

optimum emission regulation, the authority should control the each company's discharges up to the level that contamination reducing cost corresponds to the promotion of public welfare as reduction of contamination. But it is difficult to control selectively because the authority couldn't grasp every companies' limitation function between marginal cost and marginal benefit. The second, even though it caught hold of the limitation function between marginal cost and marginal benefit, it can't control selectively because of political reason, lack of information and lack of administrative ability.[5] The third, in command and control instruments, the authority should regulate on each contamination media, which can be apt to regulate double easily and make it difficult that it regulates totally considering relation with each media. And the focus of regulation can be limited only to narrow range of regulating contamination, such as typical point-source, regional environmental problem, etc.[6] The last, it imposes 'post- recovery policy' rather than 'pre-prevention strategy', and doesn't consider the interdependent relation between environmental policy and other economic policies.[7]

2-1-2. Types & Methods of Command and Control Instruments

A. Ambient Standards

The ambient standards is the criterion that is set up the pollutant concentration on desirable environmental condition which required to keep all the people's good healthy life. For the establishing method of the ambient standard, the four-level standards classified by the WHO in 1963 can be an example, which classified on the harmfulness of the ambient air environment being able to affect to human health. The first level is the concentration and the exposed time that doesn't give any influence

5) Lee Jung-jun, Green Economics, 1994, Bub-mun Co., p96.
6) OECD, Improving the Enforcement of Environmental Policies, Environment Monograph, NO.8, 1987.
7) OECD, op, cit, 1997.

directly or indirectly to human health. And the second level is the concentration and the exposed time that give adverse influence to the environment through obstructing a person's field of vision. And the third level is the concentration and the exposed time that raise change or the physiological malfunction which doesn't cause chronic disease and life-shortage. And the fourth is the concentration and the exposed time that cause an acute disease or death to the people who is very sensitive.[8)]

The Clean Air Act enacted by the EPA(Environmental Protection Agency) classified the air quality standards into two steps. The primary national ambient air standard is designed to protect human health and has the earliest deadlines for compliance. All pollutants have a separate primary standards. And the secondary national ambient air standard is designed to protect aspects of human welfare other than health where separate effects have been observed for specific pollutants.[9)]

B. Emission Standards

The emission standards is the pollutant discharge amounts which each discharge source should keep to achieve the ambient standards. The pollutant discharge amount is the MAC (Marginal Abatement Cost) curve of each pollution source matches the point P*, which is shown in the Figure 2-1. That is to say, discharge source named 1 should reduce pollution as much as Q1, and discharge source named 2 should reduce pollution as much as Q2. If the environmental authority makes every discharge source reduce same amount of the pollution(Q0), marginal abatement costs of the source 1 become P1 and that of the source 2 become P2. But it couldn't socially achieve desirable pollution reduction.

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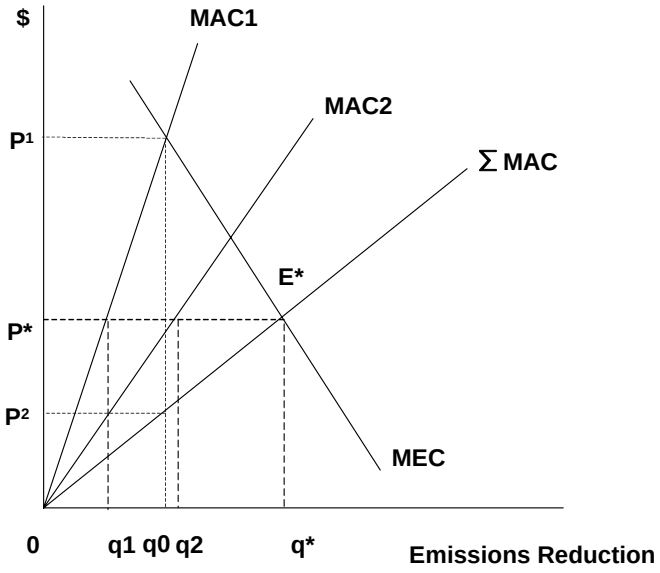
8) Kim Jong-min, Environmental Problem & Environmental Policies, 1998, Korean Economics.

9) T. H. Tieteenberg, Emission Trading - an exerce in reforming pollution policy, Resources for the Future, 1985, p. 3.

Figure 2-1. Establishment method of the emission standards



MAC : Marginal Abatement Cost

MEC : Marginal Externality Cost

But if the authority doesn't know accurately the each company's marginal abatement costs curve, the emission standards is established considering technological & economic aspect with sensibility of the environment. If it adjusts the critical load technique and the strict precautionary principle considering the technical ability, it can regulate pollutant discharge according to the BAT(Best available technology).[10] For example, in the USA and German, the BAT is that the authorities adopt because it is commercialized, credible, acceptable in control level, and the most improved technology with reasonable cost. In Britain, the BAT is the practical technology that can be supplied and be developed or demonstrated to the size which it can be executed with sufficient business confidence in the related industry. Sometimes, BATNEEC(Best Available Technique Not Exceeding Excessive Costs) considering

10) Turner, R. K., Pearce, D. W. and Bateman, I. Environmental Economics; An Elementary Introduction, translated by Cho Young-il, Comprehension of Korean Economics, Kum-mun Co., 1998.

obviously the achievement cost of specific designed discharge level is applied in Britain. This considers whether or not the cost of applying BAT is excessive over the environmental protect efficient or the characteristic of the industry, etc, with approval for it.

Recently, the pollution reduction policy by IPPC(Integrated Pollution Prevention and Control) diffuses among the OECD countries.[11] The IPPC is the coping device through grasping environment as whole one, on the base that we recognize over interrelation among pollution sources, which means the change standard-intended regulation such as typical ambient standards, waste discharge standards, etc into environmental technology-intended policy.[12]

2-2. Price Control

2-2-1. Summary of the Price Control

The price control is that the government doesn't directly intervene the environmental pollution activity such as emission discharge regulation, but indirectly regulates through economic incentive such as tax benefits and emission charges. If the economic incentive policies are used, the discharger can choose one between pollution reduction and paying charges, which makes it flexible in coping with environmental contamination problem than discharge regulation. In other words, the company reduce the contamination up to the marginal pollution abatement cost is the same as emission charges(taxes), and if it reduces the marginal cost through contamination reduction it can save the emission charges or taxes, so it continuously makes an effort on development of the pollution reduction technology or facilities investments.

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11) The Britain adopted "Environmental Protection Law" having IPC main point in 1990, the France considered the IPPC as the only standard after effectuation of the "Environmental Protection Law" in 1976, the Netherlands changed the types of pollution regulation from existing discharge regulation of each media to total regulation. Jung Hwea-sung, Total pollution management for discharger, 1996, Institute of the Korea Environment Technology Development.

12) Turner, R. K., Pearce, D. W. and Bateman, I, op. cit., 1998.

And the economic incentives have the effects reducing discharge of related pollutant in addition to reducing of regulated-pollutant. For example, if the authority lays a tax on carbon dioxide discharge created from the combustion of the fossil fuel, the discharger would change into the non-fossil fuel that discharges the less carbon dioxide. So the discharge of sulfur dioxide created when fossil fuel is burned is additionally reduced. According to the late calculation, if we reduce the discharge of carbon dioxide at 20%, the discharge of SO2 is reduced at 21% and that of NOx is reduced at 14%.[13)]

But the economic incentives regulation can't make an effect on raising of the efficiency in real environment policy unlike this theoretical analysis.[14)] First, benchmark for command and control was probably prescribed incorrectly. For example, Flexible means to limit the amount of discharge may be more efficient than bigot one when it is applied. Second, there are some cases not to be achieved its nature intention to improve the environmental quality due to the low level of emission charges in many cases. And third, the administrative costs for induction of policy, adminstration management, observation & supervision and adaptation may be paid excessively.

And also as for its efficiency from the standpoint of behavior first, all of means for limitation of discharge do not have technical obstinateness. Second, some of them enable us to develop the innovative techniques. Third, economic incentives may not contribute to technical innovation in case of low financial charge.

2-2-2. Economic Restriction Means

This is classified into two bulk categories, that is limitation of consumption of pollutants(Input) and limitation of discharge of pollutants(Output).

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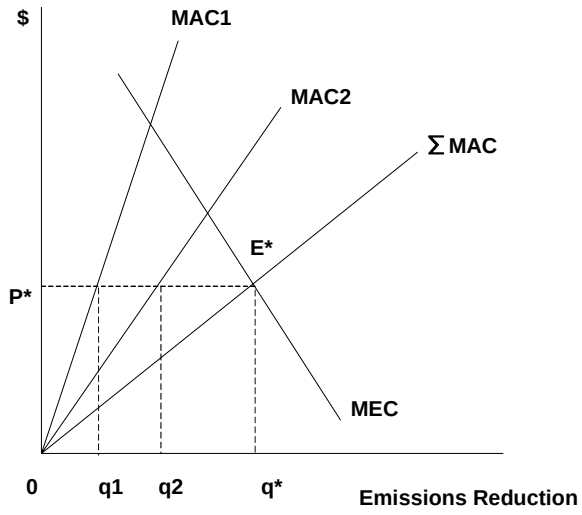
13) Bye, B., Bye, T. and L. Lorentsen, SIMEN: Studies of industry, environment and energy towards 2000, Discussion Paper No. 44, Central Bureau of Statistics, Oslo, 1989.

14) OECD, OP, cit, 1997

A. Output Charges with Pollutant Emission

This mean is based on Pigou's theory of externalities - to impose abatement costs to be needed in treatment to a person who gives rise to environmental pollution - and as enforcement of this poicy, the extent of pollution can be controlled within optimal degree of pollution which is adaptable in contemporary society. Socially optimal degree of emissions is intersection Q* of marginal abatement cost(MAC) curve and marginal externality cost(MEC) curve as shown in Fig. 2-2 and marginal abatement cost corresponding to Q* is P*. In this case Pigou asserted that if charging for P* per pollution unit socially optimal degree of emission abatement, Q* can be achieved by market function. In Fig. 2-2 if charge per pollution unit is P* pollution source 1 and pollution source 2 will be reduced to Q1 and Q2, respectively. As a result of that the total amount of emissions will be 0Q*. All that government has to do is only to make a person who brings about the pollution problem pay the emission tax and the other except for that can be solved by market function automatically.

Fig. 2-2 Pollution Reduction Effect of Emission Charges.



MAC : Marginal Abatement Cost

MEC : Marginal Externality Cost

In economic restriction for output, the final emission amounts is considered, therefore, social cost has a tendency to change into private cost and from the stand point of a person caused pollution he is restricted by reduction of discharging pollutant as well as raw material for production. For example, if government imposes a carbon tax on a person who consumes fossil fuel such as coal, he certainly becomes to try to develop tools which can be reduced carbon dioxide discharge amount such as solidification of carbon dioxide as well as to replace fossil fuel with others.

B. Input Charges with Usage of Pollution Induction Materials

This policy means that a charges per product unit is levied when specific product caused pollution is produced or consumed and mainly Product Charges. In case of carbon tax if it is levied on carbon amount contained in fuel not carbon discharging amount this is included in Input Charges.

Input Charges policy has administrative and technical convenience. In other words, it is only task to make a manufacturer pay a tax in proportion to amount product without monitoring discharge amount of individual pollution sources. And it enables government to reduce administrative cost. The other side, there are some problems. Because it does not take final demage by pollution into account it is difficult to accomplish optimal extent of pollution. And also because they can not be released from levy although they does not cause pollution it is not easy to control final dischargers strictly.

C. Abatement Subsidies

This policy means that compensate pollution causers for social benefits originated from reducing pollution with abatement subsidies. All parties to a restriction have a preference for abatement subsidies policy because it is possible to reduce pollution without burdening pollution causers and consumers of product causing pollution with an extra charge. And also abatement subsidies in corresponding to efforts to decrease pollution have incentive effects to repress

amount of pollutant discharge such as discharging tax. As a matter of fact, however, this policy has some problems in preparing financial resource and threatening the Polluter-Pays Principle.

D. Deposit-Refund Systems

Deposit-refund system is usually selected to recycle and recovery of wastes. This policy means that manufacturers, import firms or consumers of product which can be recycled and recovered easily deposit some money when they sell or purchase the products and subsequently if they recycle or recover product they can be refunded their deposit.

This is divided into two sorts. One is 'consumer deposit". In this system consumers should deposit funds when they purchase products which can be reused easily. After they exhaust them if they return them to specified place they can be returned their deposit. This system for drink vessel such as metal can, plastic bottles and glass bottles has introduced into most of OECD nations and several nations includes application range with cars used and fluorescence lamp exhausted.

The other form is 'manufacturer deposit'. Company which manufactures the goods to be wastes or marketing them should deposit funds and if they recover and treat the goods exhausted they can be returned their deposit in this system. Consumer deposit system has an incentive effect to return wastes at specified place after consuming while manufacturer deposit system has an intention to make manufacturers who determine product properties which mean quality and fabrication method and its possibility to recycle construct the recovery system.

2-3 Transferable Discharge Permits

Transferable discharge permits system is what government determines total pollution amount in consideration with natural self-purification capacity previously and allocates this among individual pollution sources and then permits dealing for individual allotments in markets. These activities allow environments to be maintained desirable state and to maximize efficiency of restriction using

market function.[15]

This system has advantages like these. First, it is possible to make financial balance stable because the cost is decreased. In general this is more economical than other policies, that is administrative order or restriction method in maintaining specific environmental quality. Theoretically it can be achieved desirable environmental quality with minimum cost. Second, it is expected that this system new technical development to reduce pollution is driven by this system. As reducing pollution using new technology a person to bring about pollution may sell his own pollutant discharging privilege. As a result of this not only another new technology to decrease pollution can be introduced but also it motivates innovation of new techniques continuously. Third is effect to be in harmony between efficiency and justice. In this system pollutant may be discharged within limitations to restrict in order to maintain specific extent of pollution, therefore it does not have an influence on its efficiency to allot discharge amount to individual pollution causers. Also, in case it is necessary to improve the environmental quality it is not difficult to achieve the environmental improvement goals if government or private environmental organizations purchase individual allotments and they do not exercise. Fourth, it has an effect to guarantee independency of individual companies. Under this system pollution causer can make a decision over long or short term plans for pollution reduction and new technology introduction autonomously.

In spite of these advantages this system can not be approved from environmentalists, industrial and governmental organizations. Its reasons are as followed. It is possible to damage environmental quality as well as immoral to permit to discharge pollutants, which were priced. In fact its execution may make some problems. Previously there is an important problem in allotting the discharge amount. In case of doing that based on grandfathering company which is discharging plenty of pollutants may be more profitable. Otherwise, unfair problems may be driven. Furthermore on-line monitoring system should be installed at all of individual pollution sources in order to keep on observing and

15) T.H. Tietenberg, op cit, 1985.

additional administrative cost for approval dealing among pollution causers and its adjustment is required.

After investigating emission charge system and transferable discharge permits system in USA and Europe, Hahn insisted that transferable discharge permits system con be expected to receive more widespread use. One factor which will stimulate the application of this mechanism is the higher marginal costs of abatement that will be faced as environmental standards are tightened. A second factor which will tend to stimulate the use of both charges and marketable permits is a "demonstration effect." Several countries have already in implemented these mechanisms with some encouraging results. The experience gained in implementing these tools will stimulate their use in future applications. A third factor which will affect the use of both of these approaches is the technology of monitoring and enforcement. As monitoring costs go down, the use of mechanisms such as direct charges and marketable permits can be expected to increase. The combination of these factors leads to the prediction that greater use of these market-based environmental systems will be made in the future. [16]

2-4. Voluntary Agreements

According to OECD this is defined as an agreement between government and individual companies, promoted by government and executed by participants who take their profits into account in order to stimulate companies to bring desirable social performance.[17] Voluntary Agreements system can be used to increase the flexibility of policy under the order-restriction system.[18]

There are many different kinds of voluntary instruments which range between those where:

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16) Robert W. Hahn, "Economic Prescriptions for environmental Problems; How the patient Followed the Doctor's Oders", Journal of Economic Perspectives, Volume 3, Number 2, 1989, p95-114.

17) Mark Storey, Demand Side Efficiency. *Voluntary Agreements with Industry.* OECD Policies and Measures for Common Action WP8 (December, 1996), p13.

18) OECD, *Voluntary Approaches for Environmental Policy* in OECD Countries, 1998, p10.

a) the parties enter into an informal understanding with government (which may be involved in a consultative or advisory capacity) but where the parties set their own targets and undertake their own monitoring and reporting on the attainment of those targets;

b) the parties enter into a form of contract between government and industry, and negotiate targets with commitments and time schedules on the part of all of the participating parties.

From the perspective of government, the aim is to encourage voluntary action with a desirable social outcome which is to be undertaken by the participant on the basis of his own self interest. This interest may be based on considerations of profit or to reduce the risk of more direct government regulation.

Voluntary instruments take many forms and are known by a variety of different names; for example, covenants, negotiated agreements, self-regulation, codes of conduct, eco-contracts. Although most often applied as means to achieve certain requirements, voluntary agreements can also apply to objectives negotiated between government and industry. Voluntary approaches are hardly ever employed in isolation and, implicitly or explicitly, are often combined with command and control or economic instruments. Typically, voluntary agreements complement existing legislation, *e.g.* 1) when legislation sets performance based objectives, leaving open the ways and means to achieve these objective through some form of voluntary agreement; 2) as experiments or forerunners for future legislation which will be shaped according to the outcome of the voluntary agreement; 3) when there is a common interest within the industry concerned.

Yet if voluntary agreements can be a useful and flexible complement to regulations, due consideration must be given to a number of potential pitfalls such as: increased difficulties in monitoring and enforcement, especially when obligations and targets are imprecise or non binding; inadequate sanctions in case of non compliance; possible higher transaction costs; possible reduced confidence of the public; risk of free riding; risk of regulatory capture when industry groups use voluntary agreements to strengthen their market position.

Ⅲ METHODOLOGY OF POLICY SELECTION FOR EFFICIENCY IMPROVEMENT

I have surveyed previous researches on methodology of policy selection for efficiency improvement, and the paper by William J. Baumol is the major source reference for my study.

3-1 The Choice of Policy Instruments

It is impossible for government to investigate all of the marginal cost curves of individual pollution sources and to select the optimal restriction method in real economic structure which has various pollution sources. And although it is possible these activities require plenty of adminstrative cost.

Weitzmann analyzed efficiencies of discharge restriction policy and economic restriction under several conditions.[19] Previous to model selection he assumed as followed. First marginal benefit curve and marginal cost curve are linear. Second, marginal benefit curve can be known exactly but marginal cost curve of company cannot be known exactly.

In this case, 1. The expected welfare gains under the two policy - the quantitative control instruments (such as marketable permits) and the discharge restriction policy (such as efluent fees) are egual, if the absolute slopes of the marginal cost curve and marginal benefits curve have the same absolute value. 2. Where the slope of the marginal control cost curve exceeds the absolute value of the marginal benefits curve, the fee approach is to be preferred. 3. Where the slope of the marginal benefits curve exceeds the absolute value of the marginal cost curve, the quantitative control instruments is to be preferred.

These facts can be proved as followed. The objectives of the regulator is to select either a reduction in emissions, q*, achieved by a set of marketable permits, or an effluent fee, f*, which yields the expected reduction in emissions that maximizes the expected value:

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19) M. L. Weitzman, "Price vs. Quantities." *The Review of Economic Studies,* XIL (October, 1974) 477-490

$$\max\ W = E\int_0^Q [\ MB(q) - MCC(q, u)]\,dq \qquad \text{----------①}$$

where,

q : quantity of emissions reduction

u : a random error

E(u) = 0

E = the expected value operator

MB = a − bq = the marginal benefits of q

MCC = w + vq + u = the marginal control cost

and * denotes optimal value

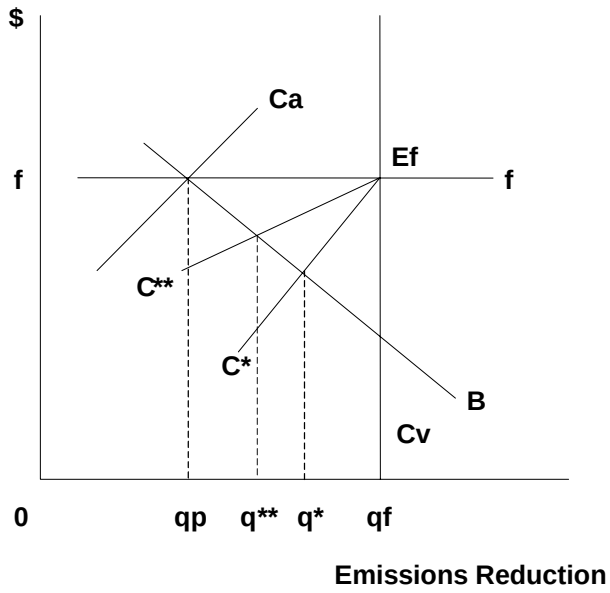
The following procedure will be to calculate aptimal values of q* and f*, and then by substituting these successively into equation ① to obtain expressions for the respective welfare gains under permits and effluent charges. The difference between these too expressions will be used to measure the expected net benefit of the one policy over the other. After obtaining the f*, the optimal fee, and the q*, the optimal quantity of permits, the equation can be derived such as:

$$W(f*) - W(q*) = E(u^2)^{(v-b)}/\,2v^2 \qquad \text{----------②}$$

Where, W(f*), is the welfare gain under an optimal effluent fee, and W (q*) is the welfare gain affered by q*. and, MB and MC curves are linear.

Since b and v are, respectively, the absolute slopes of the marginal benefit and the cost curves, equation ② shows that where these slopes have the same absolute value (b=v), the expected welfare gains under the two policy regimes are equal. Where the slope of the marginal control cost curve, v, exceeds the absolute value, b, of the marginal benefits curve, (that is, if v>b), the fee approach is to be preferred, and vice versa. Equation ② also shows that $E(u^2)$, the variance of u, affects the magnitude of the difference between the welfare yields of the two policies, but it does not affect the choice of policy instrument. Illustration for this is as followed.

Fig. 3-1 Effect of the slope of the cost function



In the figure 3-1, we see four cost curves through point Ef corresponding to effluent fee f and assciated emissions reduetion, qf. As the true cost curve shifts from Ch to C** to C* to Cv (i. e., as it increases successively in steepness), the optimal value of q moves from qp to q** to q* to qf : that is, it moves steadily further from the quantity that will be achieved under a system of permits and toward the quantity that will result under an effluent fee. We thus see that as the slope of the cost curve increase, the size of the distortion under the permit regime rises, whereas that under the fee system is diminished. In couclusion, all other thingg being equal, the steeper the curve of marginal control costs in the family of such curves meeting at qf (the equilibrium value of the reduction in emissions under the effluent fee based on the erroneous cost estimate), the greater will be the distortion lqp - qol produced by a system of marketable permits and the smaller will be the distortion produced by the effluent fee.

Fig. 3-2 Effect of the slope of the benefits function

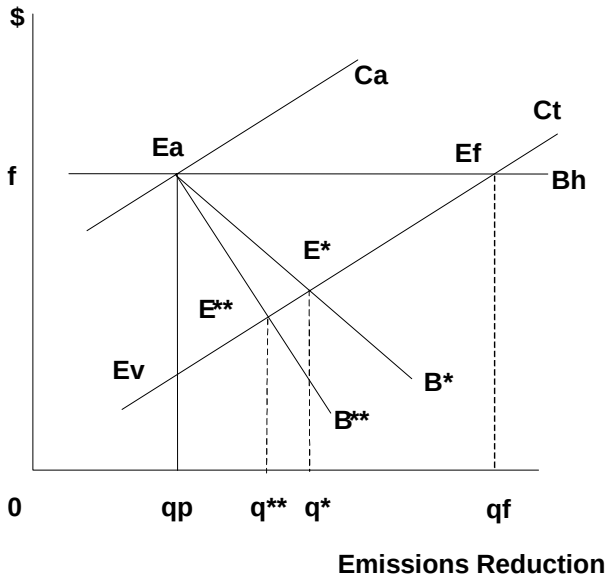


Figure 3-2 depicts four marginal benefit functions, ranging from the horizontal benefits curve, Bh, to the vertieal benefits curve, Bv, with B* and B** being of intermediate steepmess. All four curves must go though Ea since, by hypothesis, they were known correctly by the regulator and so went through his estimated optimal point, Ea. Based upon the anticipated cost curve, Ca, the regulator would thus select a fee level, f, under a system of effluent fees or, alternatively, a quantity of permits, qp, under a system of marketable permits.

We see immediately that if Ct turns out to be the true cost curve, the fee approach will result in emissions reduction of qf. We can now compare the distortions under the two system. For the extreme case of a perfecely horizontal marginal benefits curve, Bh, we see that the fee imstrument achieves the true optimal outcome, qf; the distortion under the permit regime is, in contrast, relatively large, encompassing the entire range from qp to qf.

In the other extreme case, a vertical marginal benefits curve, Bv, just the opposite is true; here, the permit approach produces the optimal outcome, and the fee system results in a large distortion(qf - qp).

The intermediate cases show that, starting from Ef, as the benefit curve grows steeper, the optimal point must move leftward along the true marginal cost curve, from Ef to E* to E** to Ev, and ever closer to the permit equilibrium, Ev. Similarly, the optimal emissions reduction must move leftward, away from qf and toward qp.

An identical argument shows that precisely the same relationships hold when the true marginal cost curve, Ct, lies above the estimated curve Ca. This completes the argument that, all other things being equal, the steeper the slope of the marginal benefits function, MB(q) (i.e., the greater the absolute value of dMB/dq), the smaller will be the distortion | | resulting from regulatory error about the cost function under a system of marketable permits, and the greater will be the distortion | | yielded by an effluent fee.

Fig. 3-3 Effect of relative slopes and the linear case

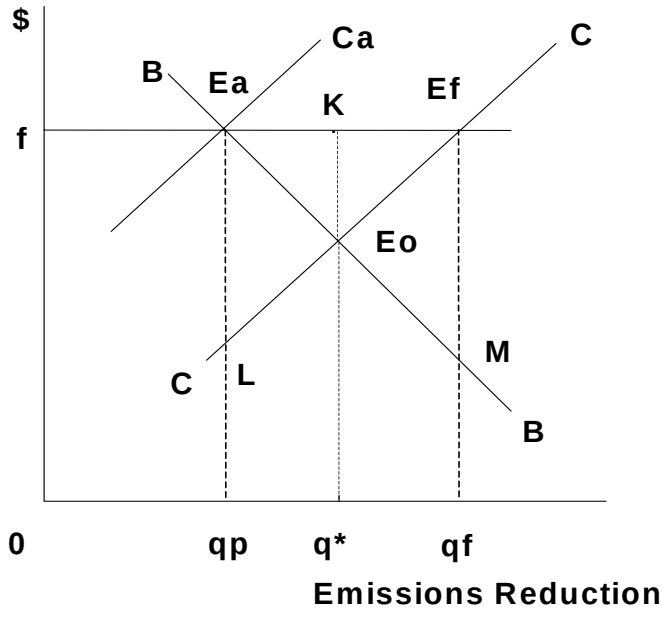


Figure 3-3 shows that the special case in which the slope of CC and BB are equal in absolute value (but no assumption is made about the magnitude of that slope). Ea is again the regulator's(mistaken) ex ante estimate of the optimum so that he either adopts effluent fee f or imposes emissions reduction qp via a set of permits.

The true optimum is qo, corresponding to the intersection of the (true) cost and benefit curves, and the emissions reduction under the effluent fee is qf. Triangles EaKEo and EfKEo are congruent, since they are right triangles, share side EoK and have another angle in common because of the assumed equality of slopes of EaEo and EoEf.

Consequently, EaK, the absolute distortion under permits, is equal to KEf, the absolute distortion under the effluent fee. This completes the proof for the case of equal slopes, that is ; when the marginal benefit and marginal cost curves are linear, marketable permits and effluent fees will produce the same absolute values of the slope of the two curves are equal. If the absolute value of the slope of the marginal cost curve is greater than that of the marginal benefit curve, effluent fees will lead a smaller distortion, and vice versa.

These kinds of analysis will be useful tools to analyze the efficiency of policies in advance. David Harrion, for example, in a study of the control of airport noise, finds that the marginal benefits from noise control are fairly constant over the relevant range. So Harrison recommends the use of effluents fees, rather than marketable permits, to regulate noise levels at local airports.[20] Similarly, it has been argued that the use of quantity instruments (in this instance, direct controls) for the regulation of automotive exhausts in the face of rapidly rising marginal control costs has resulted in large welfare losses through excessive severity of controls and the associated high costs.

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20) Harrison, "The Regulation of Aircraft Noise," in Thomas C. Schelling, Ed, *Incentives for Environmental Protection,* Cambridge, Mass.: M.I.T. Press, 1983, pp41-144

A effluents fee approach might, in this instance, have reduced social costs significantly.

On the other hand, where the marginal benefits function is quite steep, close control over quantity becomes inportant. For various hazardous wastes, for example, a marketable permit system may well be preferable since it provides greater assurance against excessive, and possibly highly destructive, emissions of such pollutants.

3.2 Mixtures of Instruments for pollution Control

Up to this piont, we have treated quantity and price instruments as alternative policy tools. However, Roberts and spence have constructed an ingenious hybrid control instruments that employs marketable permits supplemented by an effluent fee and a subsidy.[21] Based on this model, although environmental governments have insufficient informations on marginal control cost they can be attain the restriction objectives which can be closed with its optimal level met with social needs.

Assume that S≤ ≤

S : abatement subsidies per unit for any unused permits

P : price per unit marketable emission permit

F : effluent fee per unit emission

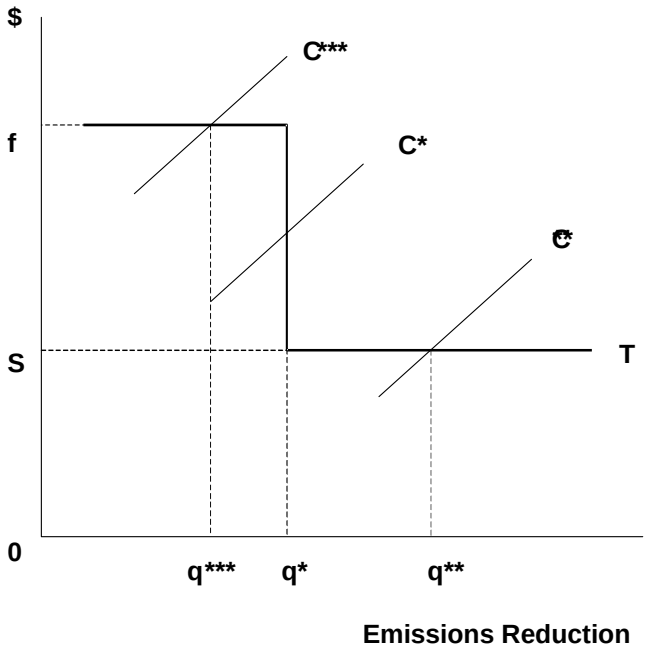
Under this assumption, if P were greater than F, no one would purchase a permit but would pay the effluent charge instead, so P would have to fall. On the other hand, if S exceeded P, it would pay to purchase as many permits as were available and hold them unused at a profit of S-P per unit ; but obviously no one would be willing to sell a permit at that price

And it becomes a pure permit system if one sets S=O F=∞ so that both the subsidy and effluent charge elements are effectively eliminated. It becomes

21) Roberts, M. J. and Spence, M. "Effluent Charges and Licences under Uncertainty." *Journal of Public Economics* V(April/May, 1976), 193-208

a pure effluent charge of any desired magnitude, k, if one sets S=F=K so that the price of a permit is driven automatically to that level.

Fig. 3-4 Model of Mixture Instruments



If real marginal control cost curve of causer is C*, he discharge q* and if there are a lot of causers then the price of marketable permits will be dealed at the price with in q* through market mechanism. However if real marginal control cost curve of causer is C*** then causer pay their effluent charge, F, and the amounts of the pollution emitted will be reduced to q***. If real marginal control cost curve of causer is C** then the opportunity cost of pollution control will be reduced, so causers reduce pollutant discharge to Q** and they can get abatement subsidies, S, from the government. So the government can achieve the optimal level of pollution abatement which can be adaptable socially using these steps rather than using single policy. In addition, these combined models enable the government to minimize errors resulted from misunderstanding the marginal control cost curve of company.

There are many criticism of these theories due to their unreal assumptions. As a matter of fact, marginal cost and marginal benefits curves are not linear in general. Watson and Ridker who used non-linear marginal cost and marginal benefits curve proved that there are no remarkable differences between effluent charge and marketable permit imstruments.[22)]

Ⅳ CONCLUSION

Government regime has selected, so far, command and control instruments because the traditional economics doesn't present clear and effective resolution on environmental problem which has externality problem. From 1980s, environmental policy using economic incentive within limited range is introduced, but it doesn't generalized yet. The problem is, because the efficiency of this environmental regulation is low, there is limit in reduction of environmental pollution getting worse forward and it can be obstructive factor against long-term sustainable development. So, it is urgent that we develop environmental policies that can maintain the desirable ambient standards and minimizes its cost.

Generally, the quantitative control policy such as establishing emission standards etc., is known more inefficient than the economic incentive regulating indirectly through controlling cost. Tietenberg, who arranged the emperical study on the efficiency of the direct regulation policy, found the control cost to be higher with the regulatory command-and-control system than the least cost means of allocating the control responsibility.[23)]

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22) Watson, W. D. and R. G. Ridker, Losses from Effluent Taxes and Quotas under Uncertainty, *Journal of Environmental Economics and Management* 11, 1984

23) T. H. Tietenberg, "Economic Instruments for Environmental Regulation" Oxford Review of Economic Policy, vol.6, No. 1, 1991.

Table 1. Emperical Studies of Air Pollution Control

Study	Pollutants Covered	Geographic Area	atio of CAC Cost to Least Cost
Atkinson & Lewis	Particulates	Louis	6.00[a]
Roach et al.	Sulphur Dioxide	Four corners in Utah	4.25
Krupnick	Nitrogen Dioxide Regulations	Baltimore	5.96[b]
Hahn & Noll	Sulphates Standards	L.A.	1.07
Seskin et al.	Nitrogen Dioxide Regulations	Chicago	14.40[b]
McGarland	Particulates	Baltimore	4.18
Spofford	Sulphur Dioxide	Lower Delaware Valley	1.78
Spofford	Particulates	Lower Delaware Valley	22.00
Harrison	Airport Noise	U.S.A	1.72
Maloney & Yandle	Hydrocarbons	All domestic Dupont plants	4.15
Palmer et al.	CFC emissions from non-aerosol applications	U.S.A	1.96

Notes;

CAC = command and control

a = Based on a 40μg m^3 at worst receptor

b = Based on a short-term, one-hour average of 250μg m^3

On the other hand, OECD said that the reasons of preferring price control rather than quantitative control instruments is in argument insisted on pre-analysis, and post-analysis doesn't prove definitely the efficiency of the price control. They said that it is harder to prove direct regulation is more effective than economic regulation, and the proof of recent economic incentive method, especially the evidence, that the marketable permits or environmental tax is more efficient, raising continuously.[24)]

24) OECD, op. cit, 1997.

Up to now, we point out that we should select the policy considering the characteristics that the effects of the policies are different on the pollution types and their economic characteristics. In some case, we find that we can achieve close to the Pareto-Superiority through mixing policies. In environmental plicies, using one environmental policy doesn't mean excluding other policies. As previously we see, we can keep abreast of command and control instruments for its performing using self-control method. So we can make the mixture of the environmental regulation keeping abreast of quantitative control instruments and price control. From now on, we should find positively mixing device of policies that minimize increasing environmental cost and achieve sustainable development.

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