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ON THE THEORY OF AN OPTIMAL ENVIRONMENTAL POLICY

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ABSTRACT

Many economists have been using economic analysis to advocate their use of either standard or effluent charges as strategies for protecting the environment. Recently a number of economists have begun to question the ability of these economic tools to accomplish the job. These economists argue that, at best, economic analysis will achieve an environmental policy which is no better than the one an ecologist could set. At worst, the economic analysis might abuse the environment and cause costly economic as well as ecological damage. This paper reexamines the theoretical approach in setting an optimal environmental policy. In this paper we find that society ought to use economic analysis in dveloping any environmental policy. Society must know the net marginal benefits of production and the marginal damage of an effluent before embarking on any environmental strategy. Such knowledge would allow society either to choose an optimal effluent standard or optimal effluent charge.

INTRODUCTION

Although many economists have for some time been advocating the use of standards or prices as methods for protecting the environment, a number of economists have begun to question the ability of these tools to accomplish the job.[1] Economists such as Müller, Pearce, Walker, and Storey have questioned the

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[1] For a more complete discussion of this literature see Buchanan [1], Muller [2], Pearce [3] and Walker [4].

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ability of economic analysis to optimally set environmental policy.[2] They claim that at best economic analysis will achieve an environmental policy which is no better than the ecologist could set by banning or greatly reducing the discharges into the environment regardless of the economic impact. They claim also at worse the economic analysis will abuse the environment and cause costly economic as well as ecological damage. This paper reexamines the theoretical approach in setting an optimal environmental policy. The paper suggests that the current wave of skepticism in the use of economics in environmental policy decisioning stems from the models used to evaluate these policy recommendations. In particular, the skepticism stems from the inappropriate measures of the social cost and benefits of an economic activity. Using an appropriate theory for measuring social costs and benefits of an economic activity, the problems of using economic analysis in environmental decisioning disappear.

A SIMPLISTIC MODEL

Environmental pollution stems from the production and consumption of goods and services. As output rises the discharge of effluents into the environment also increases. Not all of these emissions alter the environment. Low levels of production result in small effluent discharges over time. These discharges often can be neutralized effectively by the environment. This neutralization process is not costless. The real cost of the environmental neutralization of effluents can be measured as a reduction in the environment's assimilative capacity during this time period. As a result of this discharge into the environment, society has fewer options available than it did prior to this discharge. Therefore, any discharge of effluents into the environment imposes a cost on society and this cost can be measured in terms of the value of the reduced assimilative capacity of the environment.

Implicitly, society's value of the lost environmental assimilative capacity can be measured as either the consumer or producer surplus generated by the environment's neutralization of pollutants. For example, the citizens of a city which discharges untreated sewage into a river receive an unearned consumer or producer surplus from their economic activities. This city has avoided costly primary and secondary treatment of their sewage, thus the consumption and production activities in this city are cheaper since the river's environment neutralizes the city's sewage. In this situation the social costs of this effluent are functionally related to the level of discharge, R_t, and the value of the lost environmental assimilative capacity, W_t. The value of the environment's assimilative capacity is measured as the consumer or producer surplus generated

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[2] In general these economists question either the economic decision process such as Benefit Cost Analysis or the iteration process used in a tax or standard strategy or the political process involved in arriving at the optimal tax or standard. Basically, these authors implied that because of the measurement, iteration or political problems, economic analysis had little to offer for environmental policy questions.

by each unit of sewage discharge into the environment. The social costs of any environmental discharge begins with initial discharge of the effluent rather than from the first measurable social damage caused by this effluent. As output rises effluents increase and social costs from this effluent also increase.[3]

In Figure 1 the upper graph illustrates the environment's assimilative capacity as E_t. For simplicity the discharges of effluents are shown to be directly related to output such that $R_t = F(Y_t)$. As long as $Y_t < Y_{tE}$, then R_t is less than E_t. The environment can fully assimilate the effluent without ecological or social damage. However, the environment's assimilative capacity has been reduced from E_t to $E_t - R_t$. The environment's assimilative capacity is now worth less to society than it was prior to this discharge. The remaining value of the environment's assimilative capacity is then, a function of the environment's assimilative capacity, E_t, the current level of discharge, R_t and current consumer surplus generated by the environment, W_t.

$$V_t = M(E_t, R_t, W_t) \tag{1}$$

Referring to the sewage example, the social costs of this discharge begin immediately even though a small discharge into the river may be diluted by the large volume of clean water passing the city. This discharge, however minute, has reduced the river's assimilative capacity for a period of time and has reduced the river's ability to neutralize additional pollutants. The river has provided primary and secondary sewage treatment for the city. The city discharging this effluent is receiving free sewage treatment for its effluent thereby increasing her citizens' consumer or producer surplus. Thus, even when $Y_t < Y_{tE}$ in Figure 1 the economic activity is imposing social costs on the general society because the effluent being discharged is reducing the socially valuable assimilative capacity of the environment.

These social costs can be measured as the reduction in the value of the assimilative capacity of the environment V_t caused by the increase in output Y_t. In theory as long as $Y_t < Y_{tE}$ the social costs of the environmental discharge is simply measured in terms of the reduction in the value of the environment's assimilative capacity. As output increases the value of the assimilative capacity falls, increasing the social costs of the activity. If the environmental discharge exceeds the capacity of the environment to cleanse itself, the economic activity causes measurable ecological and social damage, D_t. The measurement of this damage is determined in the traditional fashion by estimating the economic losses to the harmed parties. Assuming the environment's assimilative capacity is valuable, the social costs of pollution are influenced by both the change in the value of the assimilative capacity and the damages imposed on society when these effluents exceed this assimilative capacity (see Equation 2).

$$SC_t = g(V_t, D_t) \tag{2}$$

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[3] See Coase [5], Fisher [6], Mishan [7, 8] and Peterson [9-11] for the literature surrounding the development of this simplistic model.

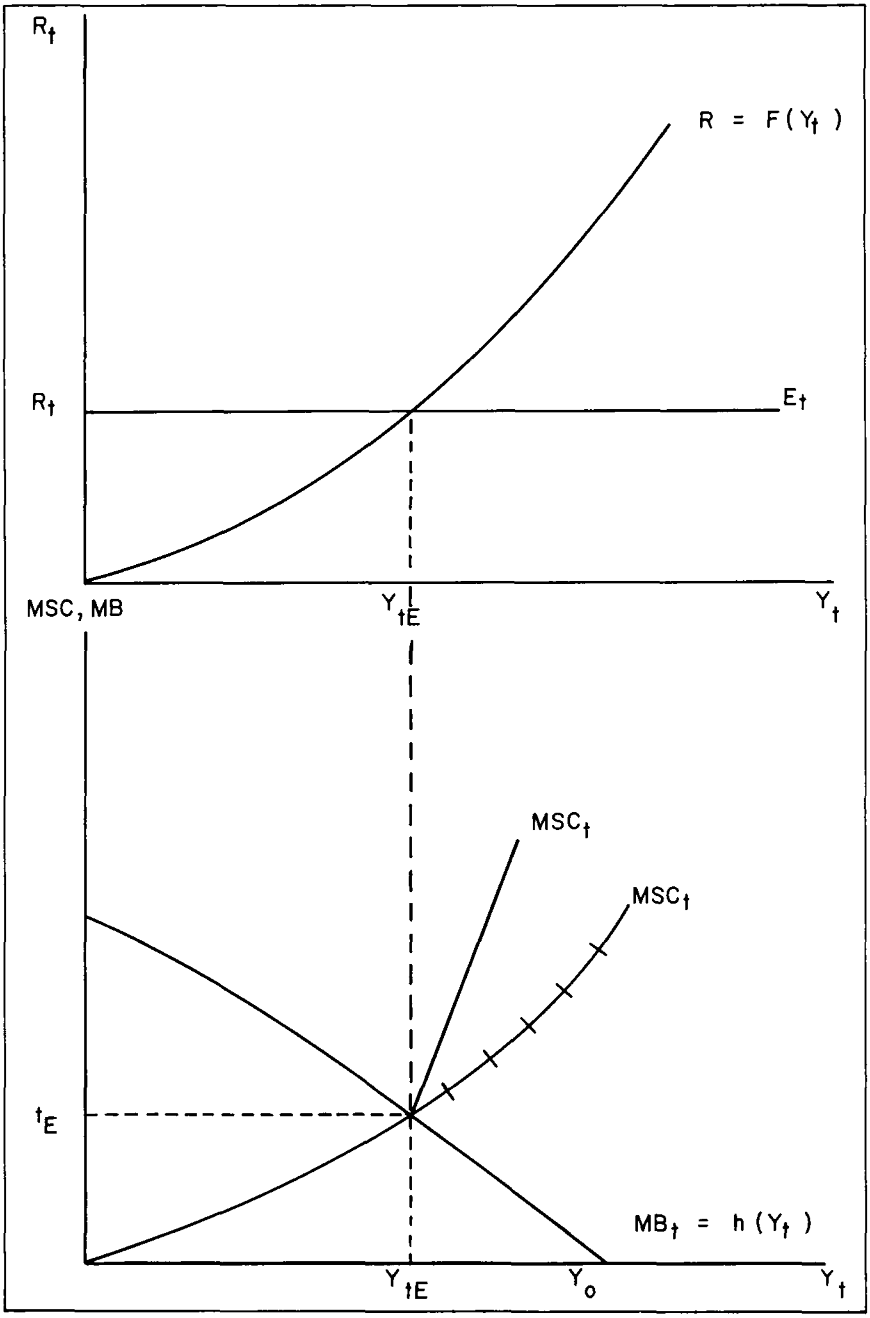

Figure 1.

In the lower graph of Figure 1 the marginal social costs of this economic activity are positively related to output, Y_t, at all levels of production. If output is less than Y_{tE} then $MSC_t = \partial V_t/\partial Y_t > 0$ since $\partial V_t/\partial R_t < 0$, $\partial R_t/\partial Y_t > 0$, and $\partial SC_t/\partial V_t < 0$. The MSC rises as output rises because the impact of the effluent's discharge reduces the value of the environment. If the level of output exceeds Y_{tE}, the level of discharge exceeds E_t and the discharge will cause measurable social damage D_t. Thus, the MSC curve is kinked at Y_{tE} and its slope increases sharply after Y_{tE} is reached.

$$MSC_t = \partial SC_t/\partial Y_t = g'\partial V_t/\partial Y_t + g'\partial D_t/\partial Y_t \tag{3}$$

Before society can determine an optimal effluent strategy society must estimate the net marginal benefits of production, MB_t, as well as the MSC_t of effluent. The MB_t represent all private and public marginal benefits minus all private marginal costs attendant with an economic activity during time period t. It is assumed that MB_t is inversely related to output since it is assumed that both the laws of diminishing marginal utility and productivity will hold for this activity. In the lower diagram of Figure 1 MB_t falls as Y_t rises reflecting the operation of these laws on this economic activity. After both MB_t and MSC_t have been estimated society may determine the optimal rate of output and effluent discharged. In this optimization procedure society should increase production only until the marginal net benefits of production equal the marginal social costs of pollution (see Equation 4).

$$MB_t = MSC_t \tag{4}$$

If society restricts output to a level less than that suggested by Equation 4, then $MB_t > MSC_t$ for this activity. Society would be better off expanding production since society's welfare will be increased. In Figure 1 society should continue expanding production until Y_{tE} is reached. When output has increased until $MB_t = MSC_t$ society has optimized its welfare from the production of Y. If society attempts to expand production beyond this level, society's welfare begins to fall since $MB_t < MSC_t$ and the social costs of pollution exceed the benefits of production.[4]

In theory, society achieves this optimal level of production and effluent discharge by using either of two abatement strategies. Society might either limit effluent discharges or set effluent taxes. If society limits effluent discharges to R_{tE}, then society would be forced to restrict output to Y_{tE} insuring that 4

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[4] It is realized that MB = MSC may occur at outputs other than Y_E. Society may either underuse or overuse the environment's assimilative capacity and still meet the benefit cost criterion outlined here. In any event, society may destroy the assimilative capacity of the environment and still act rationally if it has full information and has accurately measured all benefits and costs. Society would still be setting an optimal environmental policy but the process would be more complex. Society would have to discount the value of the assimilative capacity of the environment for future generations. This problem is handled in another paper.

would hold. On the other hand, society might impose an effluent tax of t_E on the discharge of R into environment. This tax would increase the cost and price of Y to the public and ultimately restrict the sale of Y_{tE} again insuring that only R_{tE} is discharged into the environment. Although society may use either taxes or standards to reach Y_{tE} this author has shown elsewhere that over the long run the effluent tax is a superior policy tool because it encourages improvements in abatement technology.[5]

INDUSTRY AND FIRM RESPONSE TO AN EFFLUENT TAX

For simplicity, assume that the economic activity is undertaken in perfectly competitive market conditions in a constant cost industry with all firms in long run equilibrium. Prior to the initiation of an effluent tax the industry and each firm in the industry would be overproducing Y and selling it at too low a price. In Figure 2 the industry would product Y_t and sell it at P. Each firm in the industry would simply respond to these market forces and supply y_t at a price and cost of P. At any other price or output market forces would be set in motion which would alter production, price, or both, until each firm was producing at the lowest point on its average cost curve.

If society now imposes an effluent tax on the output of Y and insures that the tax is determined in the manner outlined in the previous section, each firm's marginal and average costs would shift to $MC_1 + t_1$ and $AC_1 + t_1$ respectively. In addition, the industry's supply function would shift to $SC_1 + t_1$. Imposing the effluent tax on the industry forces the industry to consider the social costs of its production into its cost matrix. This tax reflects the firm's MSC_t of producing this output and this tax reflects the social damage caused by the industry's effluent at all levels of output. At low levels of output the tax is low because MSC is low, but as output increases the MSC_t rises increasing t. Therefore, the firm knows explicitly what its tax rate will be at all levels of production. Society has optimized its welfare and the firm and industry have maximized their profits at each rate of output given the tax structure. In the long run firms respond to the higher costs of production by cutting output back to y_{tE}. The industry responds by cutting output to Y_{tE} and raising prices to P + t. Both the firm and industry are in equilibrium but producing less and selling at a higher price necessary to cover the total costs or production which includes the social costs resulting from the discharge of effluents into the environment.

EFFLUENT TAX AND ABATEMENT STRATEGY

Under these conditions, some economists are worried about the firm's or industry's adoption of an optimal abatement technology. This worry is very

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[5] See Peterson for a complete discussion of this idea [12].

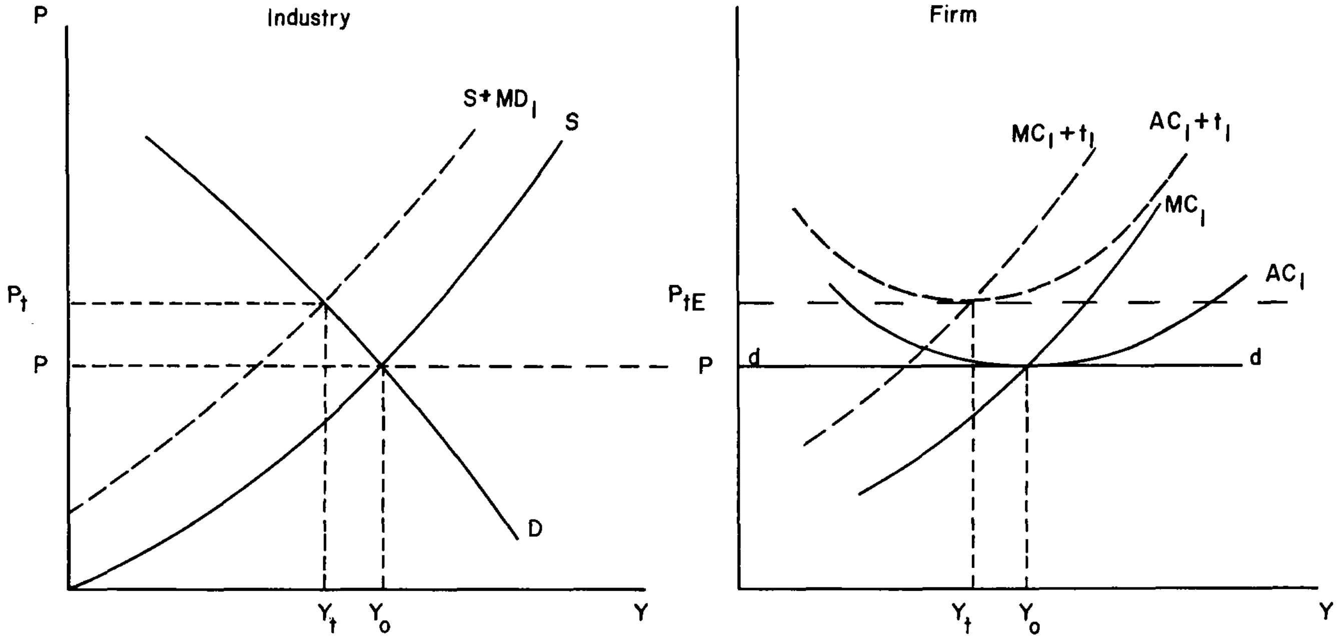

Figure 2. Perfect competition.

important to the firm and industry but of no importance to society. In the long run the forces of supply and demand will eliminate any firm which adopts an inefficient abatement strategy.

To illustrate this point, suppose the firm identifies an effluent abatement strategy which will shift the firm's discharge function down from R_1 to R_2 (see Figure 3). If the abatement strategy were installed, society should respond by lowering its tax from t_1 to t_2. The firm must now compare this tax saving with its increased costs of abatement to determine whether the installation of the technology is profitable. Clearly if the firm finds that its costs plus new tax are *above the prevailing price including the original tax,* $P_1 + t_1 < AC_2 + t_2$ *then* the firm will not install the new abatement technology since it would reduce the firm's profits. The firm would avoid installing this or any inefficient abatement strategies. Inefficient strategies being identified as a strategy which is more costly to install than the benefits it would generate to the firm and ultimately society.

Suppose a firm finds that the new abatement technology reduces its costs plus new tax to $AC_2 + t_2$ and $MC_2 + t_2$ in Figure 4-b. Here the firm would find the new strategy a profitable installation in the short run since it reduces costs and increases its profits. The firm would increase production from y_1 to y_3 and generate positive economic profits as long as price and the old tax prevailed for the industry. In the long run other firms would observe this firm's profits and adopt the abatement strategy as well. The industry's output would rise to Y_2 and the firm's output would fall to y_2 while economic profits would leave the industry. This level of production again generates an optimal level of effluent R_2 in Figure 3. Society has maximized its welfare in the production of Y since $MB_t = MSC_t$ at Y_2 output and discharge of R_2.

If yet a third abatement strategy is now discovered which further reduces the damage function and effluent tax, firms within the industry again must compare the new cost and tax information with the existing price structure. Assuming that $P_2 + t_2 > AC_3 + t_3$, some firms within the industry will now adopt the abatement strategy. Naturally, firms that have just adopted the old strategy face a very costly decision. This decision has been discussed at length in the Walker-Storey article.[6] *Should they continue using the old strategy or adopt* the new strategy? Any firm in this industry faced with this investment decision can use the Walker-Storey iteration process to decide. In the long run process, however if these firms choose the old strategy they will be forced out of business since the industry price and tax structure will fall below the inefficient

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[6] Walker [4] *discusses the practical problems which a firm or industry faces when* attempting to adopt an optimal abatement strategy under an effluent tax system suggested by Baumol [13]. The iteration problems which Walker foresees are due to the incomplete knowledge of society's effluent tax strategy. If society sets its taxes based on the discharge function R as suggested in this article the firm could rationally evaluate various abatement strategies.

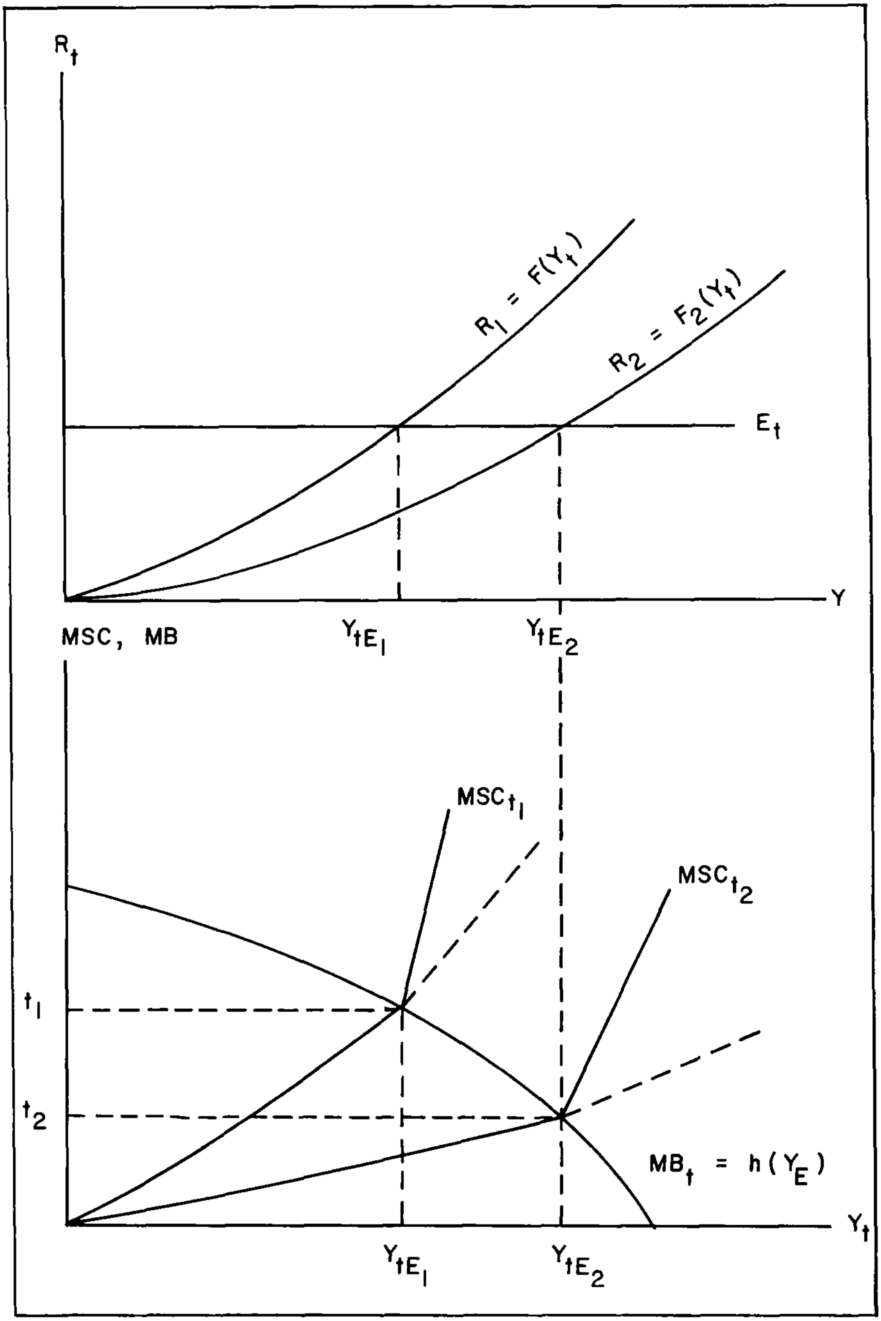
R_t
$R_1 = F(Y_t)$
$R_2 = F_2(Y_t)$
E_t
Y
MSC, MB
Y_{tE_1}
Y_{tE_2}
MSC_{t_1}
MSC_{t_2}
t_1
t_2
$MB_t = h(Y_E)$
Y_t
Y_{tE_1}
Y_{tE_2}

Figure 3.

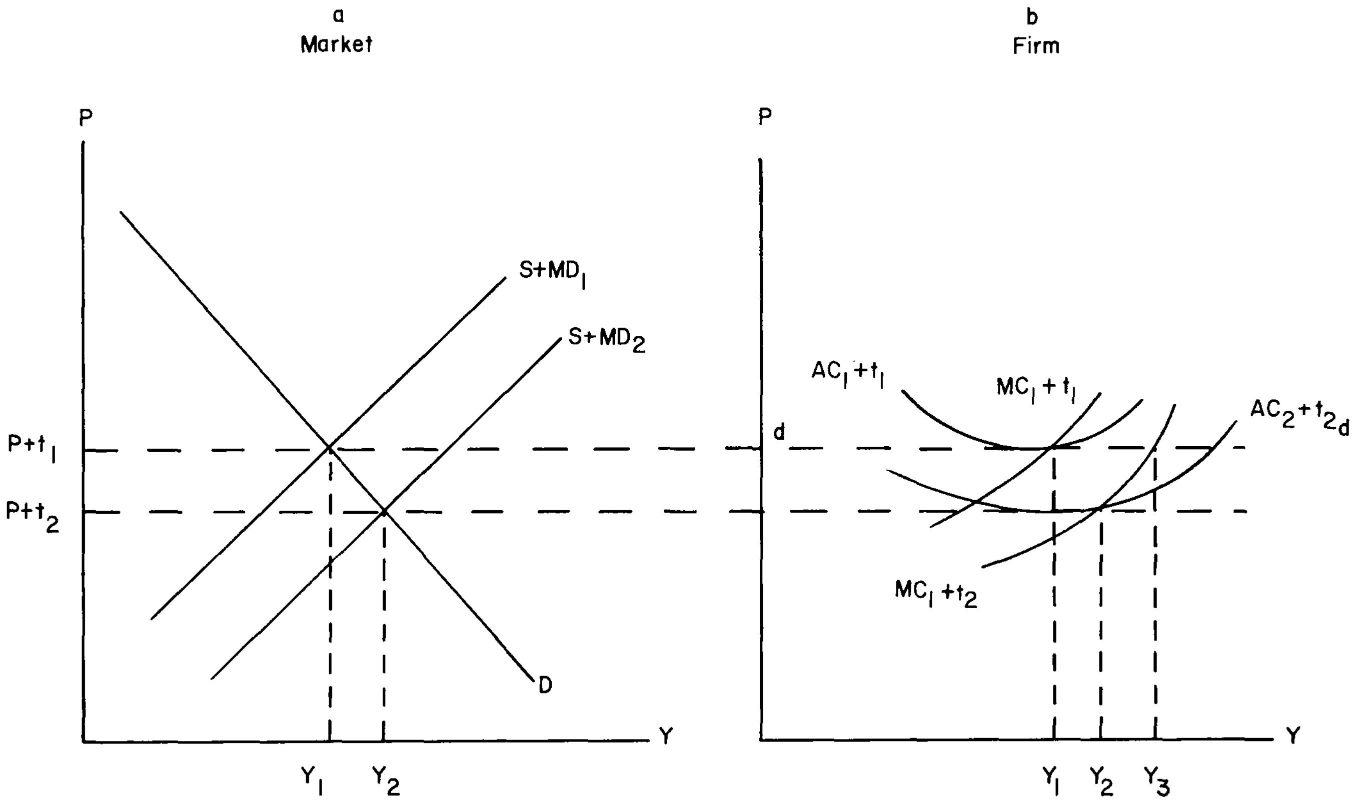
a
Market
b
Firm
P
P+t_1
P+t_2
S+MD_1
S+MD_2
D
Y
Y_1
Y_2
P
d
AC_1+t_1
MC_1 + t_1
AC_2+t_{2d}
MC_1 +t_2
Y
Y_1
Y_2
Y_3

Figure 4.

firm's costs and structure. From society's point of view this is as it should be, the inefficient polluting firms in the industry should be forced out of the business.

CONCLUSION

In conclusion, society does not need to know the costs of each abatement strategy as suggested by Walker and Storey or implied by Baumol and Oates before deciding on an optimal tax to be levied against a particular effluent [14]. Society must know the net marginal benefits of production and the marginal damage of an effluent before embarking on effluent tax strategy. Such knowledge, of course, would allow society to also choose an optimal effluent standard as a strategy. This author has shown elsewhere that an effluent standard will freeze the abatement technology into a legal code.[7] If society then finds a new abatement technology, there will be no incentives for industry to adopt the technology. Thus, the effluent tax strategy seems to offer the only efficient long run solution to our world pollution problems. An effluent tax strategy may be implemented but faces serious political problems [1]. These problems stem from the reluctance of industry and society to accept the results of the higher prices and costs which the tax strategy portends. Industry supports the effluent standard strategy because it is shown to be more profitable. The consumer pays a high price for his goods because industry produces less but the industry rather than society receives the extra revenue.

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[7] In this paper Peterson and Lichty show that both an effluent tax and standard are optimally pollution strategies at a given point in time [12]. Over time the effluent tax encourages the adoption abatement technological changes. Standards retard abatement technological changes, effluent standards create artificial monopolies for polluting firms and industries and drive up prices. The economic value created by the productive aspects of the environment is paid to the polluter. Thus, standards increase the polluting industries profits. These profits then are used to prevent change of technology which might reduce the industries use of the environment in its productive process.

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