Models for determining taxes on pollution – a major goal for environmental purposes

M. Bulearcă, Marina Bădileanu, C. Popescu, M. S. Muscalu

Abstract – Given that ecological research has begun to study environmental phenomena and interpret data and information on economic and social relations taking into account environmental restrictions, as to draw conclusions about the effects that such restrictions have on economic and social life, this paper intends to determine the extent to which costs provide maximum benefits for quality of life in general and human in particular.

Keywords – environment, marginal cost and benefit, models, taxes on pollution

I. INTRODUCTION

Ecological research, lately intensified, highlighted the systemic nature of planetary lifetime, the close interdependence between environment and human activities and the causes underlying the emergence of imbalances in the whole system, with negative effects for life in general and human in particular.

Moreover, economic research has begun to study environmental phenomena and interpret data and information on economic and social relations taking into account environmental restrictions, to draw conclusions about the effects that such restrictions have on economic and social life, including quality of life, and human effects on improving environmental conditions.

A number of theorists and practitioners of environmental movement from different developed countries stresses that safeguarding nature has two objectives: to preserve the fundamental resources - air, water and soil - in the form and proportions necessary for human welfare; and to preserve the elements necessary for human development throughout the aesthetic, educational or scientific approach.

Progress made by Romanian researchers in this area is reflected in crystallizing the idea that environmental quality is a defining component of life quality.

Implications of environmental quality on quality of life have intensified the economic problems of environmental costs versus the benefits obtained. Natural resource allocation may not only maximize the environmental effect, as most often say ecologists. Allocation of resources should consider finding an optimal level effect in the interest of all human society.

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Following observations and empirical studies, it was found that there are relations of dependence between the degree of reduction of pollutant residues, on one hand, and cost and the benefits to be achieved by total control and actions to reduce pollution, on the other hand. It has been demonstrated, for example, that the cost of pollution abatement in total activity describes the degree of pollution as an exponential curve.

The first steps to reduce the concentration of waste without polluting brings the most important effects; then additional measures to reduce waste with the same beneficial effects on life quality, requires spending more. Also it has been found that the evolution of positive effects on life quality for achieving different levels of pollution describes, roughly, logarithmic or semi-logarithmic curve form. Therefore, the problem requires continuously determining the extent to which costs provide maximum benefits for quality of life.

II. MODELS FOR DETERMINING TAXES ON POLLUTION

From the economic point of view, the environmental protection expenditure maximum level that can be made to is the point where total cost equals the total positive effects. But careful analysis reveals that a zero difference between the benefits and costs would be reached in the foreseeable future, unless they would remain the same or industrial technologies would grow slower than the pace of deterioration in the environment.

Reality demonstrates that the progress on improving or introducing new technologies in the last three decades are more pronounced towards the elimination of pollution, clean recovery of new resources or substitution of polluting resources with other clean or cleaner resources.

The unsatisfactory situation reached regarding the advanced status of pollution in some countries and regions is due not to the lack of technological solutions, but especially to the long time neglect of such important issues as a result of either ignorance of their scale phenomena or negative failure consequences, or insufficient economic mechanisms put in the service of immediate interests, without taking into account the perspective of life quality of individuals and entire communities.

In order to have a better management of natural resources, on one hand, and to reduce environmental pollution, on the other hand, the use of instruments for this destination is detailed below.

In the beginning we have to understand the various costs involved in pollution control. Regardless of the original way for financing this remediation action, the population has to bear a burden on the following four ways:

1) as tax payers, when bearing high taxes because there are grants awarded to companies that install pollution control installations and equipments;

2) through increased products prices, because as long as subsidies cover only a fraction of the remediation equipment cost, the other part having to be supported by companies that have installed them, operators “passes” some of this burden to the public;

3) through additional payments in the future, because at the companies’ already paid level for pollution control equipments and lower investment in other equipments, increase in productivity and production is reduced.

4) through loss of jobs, due to the fact that pollution control standards determine closing plants, and although the highest costs public occur, even those who live near large pollution prefer pollutants than job loss.

Thus, in one way or another cost control pollution affects us all.

Because is so expensive to control pollution the cheapest methods have been chosen (see fig. 1). First we must understand why government intervention is essential. Why government facilitates private market? Why we can not count on the "invisible hand" of Adam Smith in limiting pollution?

Good’s marginal cost to society, pointed by the long arrow $MC_{S,}$ includes both internal marginal cost of producing company (filled arrow), and the marginal external cost of producing company (shaded arrow).

Pollution: an external cost. When there is pollution, private and social costs differ. To understand why, let’s consider a pulp and paper mill located on a river. Paper cost for the society includes not only company’s private or internal production cost, but the cost of downstream companies that have to face water discharges made by upstram companies. While the factory has to pay for the cost of domestic production, any downstream cost is external to such operations, since the cost must be borne by the others.

Internal or private costs are costs incurred by those who actually produce or consume the good.

External costs, also known as neighbor costs or spillover costs are costs incurred by the others. Pollution is such an example.

Let’s consider a simple case. Suppose that each unit is treated with a quantity of fluid which is then released as waste in the water. Assume also that each unit of this fluid causes constant damage downstream. As such, each unit of output produced requires a constant external pollution cost, shown in figure 1 by the short shaded arrow. When is added to internal cost borne by the producers (filled arrow MC), the result is the long arrow MC_S, which is the marginal cost to the society of this good. MC_S is constantly higher than MC because of the assumption on constant external cost per unit of output produced.

Pollution control: the simple case. When we have such an external cost, even in a perfectly competitive market economy it results a poor allocation of resources as seen in fig. 2.

Before applying antipollution tax, industry supply is S_1, which reflects only the private internal costs of producers facing the sellers. This supply equals the demand in point E_1 through an output Q_1. This production is inefficient because the marginal social cost exceeds the benefit for all productions between Q_2 and $Q_{1.}$

For example, last unit Q_1 does not deserve to be produced; its benefit, as shown by the shaded arrow below the demand curve is less than the costs to society (also the shaded arrow plus the filled arrow below curve MC_S). Loss of efficiency is the sum of these filled arrows that is the shaded triangle. After apllying tax r, producers are forced to face both internal cost and external one, so their supply curve shifts upward from S_1 to $S_{2.}$ D and S_2 now have a balance in $t_{2,}$ through the output $Q_{2.}$ This is efficient because the marginal cost and benefit are equal. Efficiency gained by reducing output from Q_1 to Q_2 is the elimination of shaded triangle.

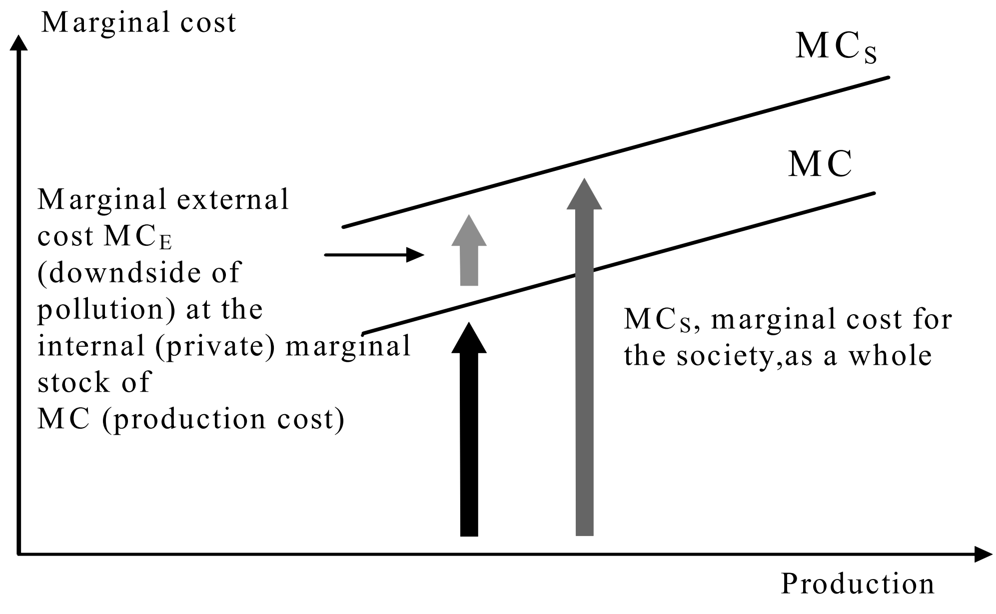

Fig. 1. With pollution, private and social costs differ

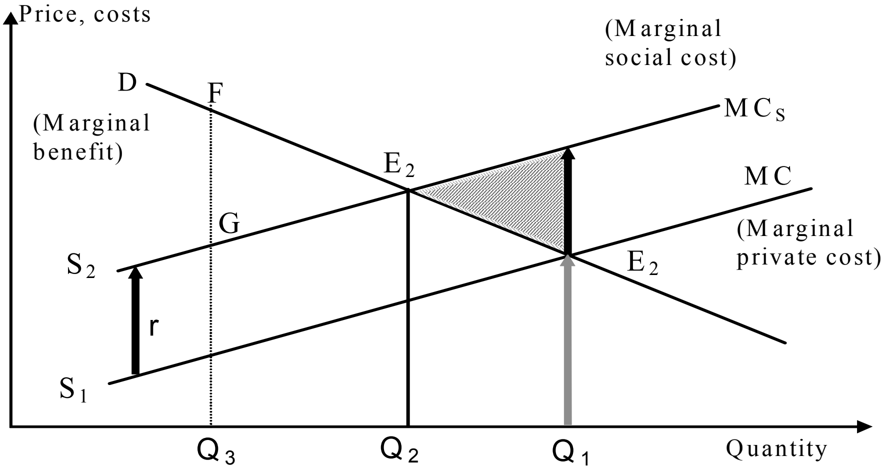

Fig. 2. Loss of free market efficiency when there is an external cost

In fig. 2, MC and MC_S are reproduced from fig. 1, and the demand D is the marginal benefit of this both private and social good. S_1 shows that firms are willing to offer. This curve measures the internal private costs – the only costs firms face in their decision to offer. With the demand D and supply S_1, perfectly competitive equilibrium is reached in E_1.

For society, E_1 is not an efficient income because it only equalizes the marginal benefit and marginal private cost. An effective solution requires that the marginal benefit equals to the marginal social cost $MC_{S.}$ This happens in E_2, at a lower production $Q_{2.}$ We conclude that in a free market, competitive firms produce too much of a pollutant good Q as compared to effectively quantity Q_2. Is in the interest of society to decrease the production of these goods and use resources to produce something else.

To confirm that Q_1 is an inefficient production, worth noting that the benefit of the last unit produced is shown by the shaded arrow below the demand curve. However, its cost is even higher, since they include both private costs (the same shaded arrow) and its external costs (indicated by the filled arrow). So, this filled arrow represents the net loss in producing the last product unit $Q_{1.}$ As long as there is a similar loss in producing of each unit "in excess" between Q_2 and Q_1, the total loss of efficiency is measured by the shaded triangle.

In this case, there is one possible way to solve the situation: the manufacturer imposing a uniform tax equal to marginal external cost shown by the filled arrow. Thus, the tax "internalize" the externality: the manufacturer is forced to face both external costs and internal cost. As a result of this tax, supply curve shifts upward from S_2 to S_1: for confirmation, we have to remember that the offer reflects the marginal cost, and he stood by the size of the tax to be paid. The new equilibrium is in E_2, where the demand and new supply S_2 intersect. This new production Q_2 is efficient because marginal benefit equalizes the social marginal cost. Finally, the gain in efficiency of this taxation policy is the shaded triangle, the loss of efficiency at the beginning, which has now been removed. In short, as a result of this tax, the company receives a benefit that otherwise the market would not offer: pure water.

There have been suggested several ways to reduce pollution. One is setting a limit on the production of polluting companies; another is the introduction of property rights.

Such a limit may or may not solve the problem; in fact, is better than to do nothing. For example, suppose that production is limited to $Q_{3.}$ Considering the situation shown in fig. 1, one can demonstrate that producing too little, a loss for society will occur, that is triangle FE_2G. As long as the loss will exceed the initial loss, in this case the improvement will be worse than in the original case.

It may be noted also that a greater restriction of production will lead to a higher loss in efficiency. Thus, an arbitrary limit of production may be an ineffective policy. A better approach - if pollution costs can be estimated - is to impose taxes on these amounts. Then, the correct degree of pressure will be applied on the market to push back from production from the initial Q_1 to efficient production $Q_{2.}$

Pollution control: the complex case. In practice, policy makers must deal with situations more complicated than those shown so far. First, pollution is not from one polluting industry. Second, pollution and production are not only linked to a situation similar to that already presented, in which each additional unit of production generate an equal amount of pollutants; in most cases the latter varies. A good can be produced with large amounts of pollutants that are discharged without any restrictions in water or air. However, if the waste is treated, or when using pollutant fuels, this situation will result in a lower amount of pollutants.

Consider a company that treats its waste, and use cleaner fuel but more expensive. This company reduce pollution, but at a certain cost. This cost to reduce pollution for all companies in an area shown in fig. 3 as curve MCR (where R is to reduce pollution).

Q_1 is the amount of pollutants that might occur in the absence of control measures. By shifting us back to the left of MCR, we notice the cost of reducing pollution for an additional unit - for example, by installing pollution control equipment. So, if pollution was restricted on the way back to $Q_{4,}$ any greater reduction would involve very expensive antipollution measures, implying a cost showed by the high filled arrow.

ISBN: 978-960-474-253-0

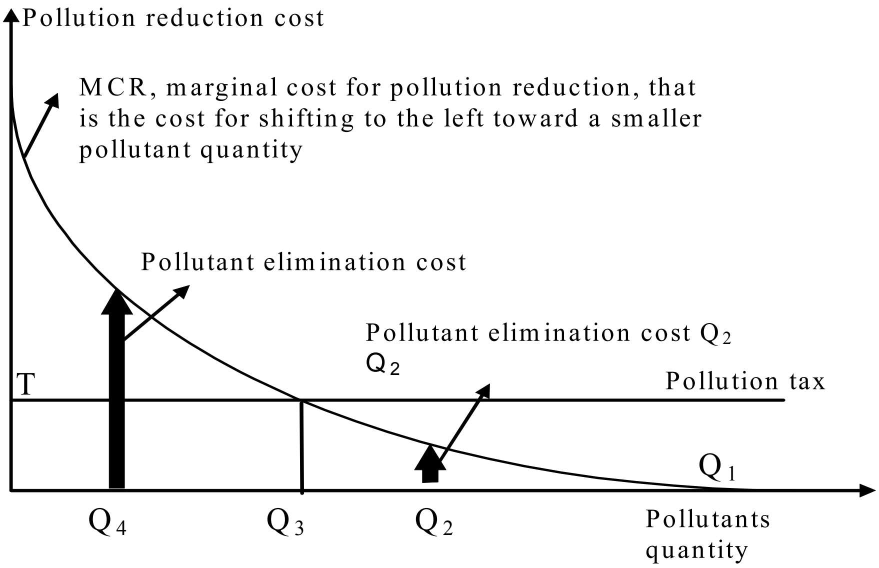

Fig. 3. The cost of reducing pollution and the effect of a tax

If a pollution tax T is applied, companies voluntarily reduce their pollution, shifting from Q_1 to Q_3. As long as they are still at the right side of Q_3, they will continue to reduce pollution because its cost (eg, short filled arrow) is less than the cost to pay the tax. However, they will not shift to the left of Q_3. In this side, it costs more to reduce pollution (high filled arrow) rather than continuing to pollute and pay the tax T.

Through Q_1, has been designated the amount of pollutants that occur when no restriction is imposed. As it reduces pollution, firms shift to the left on curve MCR. At first, remediation costs are lower. For example, the quantity Q_2 of pollutants can be removed at a lower cost pointed by the short filled arrow. However, further reducing pollution, the lower curve becomes higher as companies shift to the left.

III. TAXES ON POLLUTION – A MAJOR GOAL FOR ENVIRONMENTAL PURPOSES

Until a few decades ago there were few restrictions on pollution. Therefore, companies preferred to discharge pollutants instead of treating them. The result was the amount of pollutants Q_1.

To prevent this situation, the government wants to dramatically reduce pollution. Suppose they want to reduce by half, from Q_3 to Q_1. Policies are as follows:

Option 1: Pollution tax. Suppose the government imposes a tax on emission – ie, a tax on each unit of pollutant discharged in the environment. Specifically, in figure 3 suppose that T is the tax payable per unit of pollutant. Then, businesses eliminate pollution in the right side of curve MCR, where costs are lower to curb pollution (eg small filled arrow), rather than continuing to pollute and pay the tax T. However, pollution is reduced simply to the Q_3 where curve MCR intersects the line of tax. Left to this point, the cost of reducing pollution is high, as illustrated by the large filled arrow. Indeed, the cost is higher than the tax T. So in this area, companies can be encouraged to pay taxes and continue to pollute.

Although “taxes on emissions" have been much supported by economists, still they are not often used. However, in a similar approach, there are some cases in which comanies are required to pay pollution - even if payment is not directly related to each unit of pollutant. For example, EPA (US Environmental Protection Agency) Superfund, a multibillion dollars program for random chemical waste cleanup, was initially financed by imposing taxes on companies that pollute heavily.

Option 2: A physical limit imposed on the pollution level of each company. A question may arise: Why to have so many problems with setting a tax on pollution, as in figure 3, as long as the pollution can be reduced by the same amount through a simple and direct control, ie by asking each company to reduce pollution by half?

The answer is that, even if this approach would lead to the same abatement level of pollution, this situation would involve higher costs of remediation (cleaning), as will be further explained.

Not all companies face the same pollution abatement costs by applying a tax, pollution is reduced by companies that can achieve this at *the lowest cost,* ie firms at the right of Q_3. Companies from the left of Q_3 will continue to pollute. However, if all companies would be required to reduce pollution by half, companies from the left of Q_3 should in this case, to participate, even at the cost indicated by the filled long arrow.

As such, the advantage of a tax is that "it lets the market to go". For companies that respond at applying the tax, pollution is reduced by those companies that will do this in the cheapest possible way. Thus, the company devotes fewer resources for cleaning. Gains can be substantial. Wallace Oates of the University of Maryland assumed that the pollution tax would cost the company 75-80% less than a policy of demand (taxation) of all companies to reduce pollution by the same percentage.

Which of these two policies have been adopted by governments? The answer is surprising: rather than let the market work by the existence of several taxes on pollution, governments have relied primarily on regulatory controls. Physical limits imposed by the pollution were introduced for certain companies - a policy, as shown, involving undue additional costs.

ISBN: 978-960-474-253-0

There are recent encouraging signs that governments are moving towards a third solution, a compromise that allows individuals to set limits on pollution, but at the same time, to let the market work and, as such, to avoid undue additional costs.

Option 3: Physical limits imposed on the contracting of the pollution permits on pollution emissions. The third option is that the authorities set a specific limit on the amount of pollutants allowed to each company. For example, each company is allowed to pollute only half the level of pollution in its past. So far, the situation is similar to that of Option 2. At this time intervenes the turning to let the market work: companies are allowed to buy and sell "pollution" permits.

It can be shown that in a perfectly competitive market, permits will be sold at the right price T. Companies at the right of Q_3 gain by selling their permits at the price T and by remediation actions at a lower cost shown by the short filled arrow. For the companies at to the left of Q_3 is cheaper to buy permits at price T to continue to pollute than to spend more on remediation, costs represented by the large filled arrow. Thus, pollution is lower only for the companies at the right of Q_3, which may realize it at the lowest costs. So, in Option 3 as it can (easy) sell permits on the market, pollution can be reduced at the same low cost as in Option 1 that involves a pollution tax.

Therefore, the effects of Option 1 and 3 are higher than those of Option 2. Only in Option 2 – where all companies are required to reduce pollution with a fixed unit - the high cost of remediation is taken only by the companies at the left of Q_3.

In these circumstances, the general principle is: ***Pollution can be reduced to lower costs if the government gives way to market forces.*** He can change the incentives by imposing a tax or applying permits sold on the market and then allowing businesses to operate and respond to the new conditions created.

Companies are the only one the most aware of their cost levels and thus are best able to choose the path that will minimize these costs.

Basic conclusion is: as Option 2 does not use market principles, is more expensive than Option 1 or 3. But comparing Option 1 to 3, which is preferable?

A comparison between Option 1 and 3. These two choices differ by an important issue. In Option 1 companies are penalized. If they cease to pollute, they have to pay the cost of remediation. In any case they are inversely affected by the applying of pollution tax.

However, in Option 3, through the permits sold on the market, companies do not neccessarely have to lose. Indeed, those with lower costs for remediation actually gain.

They can sell pollution rights for a price T that is greater than the total cost for remediation. While companies with high costs for remediation are affected in the opposite direction, they do not lose as much as they would lose by imposing a tax like the one in Option 1. Why? In Option 1, they have to pay tax T for all pollutant emissions. In Option 3, they do not bear a cost for some of their pollution – that is the pollution which is covered by free permits which they were secured.

The fact that polluting companies prefer applying Option 3 makes the application a much more attractive option for the government.

Productive activity does not influence too much on it and can assimilate easily into the legal framework. Thus, pollution can be controlled without interminable delays.

However, even Option 3 poses a problem. Why even activities that have polluted in the past are entitled to permits and some may even sell them? In other words, some companies may benefit from pollution done in the past? This suggests that, on an equal basis, Option 1 is preferable because it penalizes the old pollution instead of rewarding it.

Therefore, it was assumed that the government has set as a goal to reduce pollution by half, to Q_3. Why not by third or three quarters or other percentage? Below is shown how objectives can be prefixed.

How much pollution can be reduced? In fig. 4, MCR is reproduced from fig. 3. Moreover, we have here MCP, which is the ecological cost of additional units of pollutants. The best goal is to restrict pollution to Q_3, where MCR equals MCP.

The two curves, MCR and MCP should not be confused. MCR is the cost of *reducing* pollution - for example, the cost of pollution control equipment.

On the other hand, MCR is the cost of *allowing* pollution. As long as there is only a small amount of pollutants - Q_4, say - the marginal cost to allow pollution (MCP height) is small. First wastes that are discharged in a flow are generally absorbed by the environment. As pollution increases, emissions increase and become more dangerous; that means we move to the right, and the MCP curve increases.

With these two curves, the best goal is to reduce pollution by Q_3, where MCP equals MCR. Any other quantity is not desired, as can be illustrated by the case in which pollution is left completely open and eventually reaches Q_1.

For all quantities of pollutants at the right of Q_3, MCP is higher than MCR, so it's a mistake to allow pollution any further. To assess the social cost of this mistake we may consider such a quantity, say Q_2.

The cost of eliminating this quantity of pollutants is the height of curve MCR, shown by the empty arrow. This is less than the cost of allowing further pollution (the height of curve MCR that is both arrows). Therefore, the net cost of allowing such pollution is the filled arrow. If we sum up the costs of all quantities that are similar between Q_3 and Q_1, the result is the shaded triangle that is the loss to society by allowing pollution to exist further to unchecked Q_1 instead of limiting it to Q_3.

On the other hand, a policy to reduce pollution at the left of Q_3 causes a loss also. For example, if pollution is reduced to Q_4, the cost of the last quantity is the height of curve MCP above of Q_4. However, this last unit of pollution exceeds the cost of disposal (the height of curve MCR). Removal is a mistake.

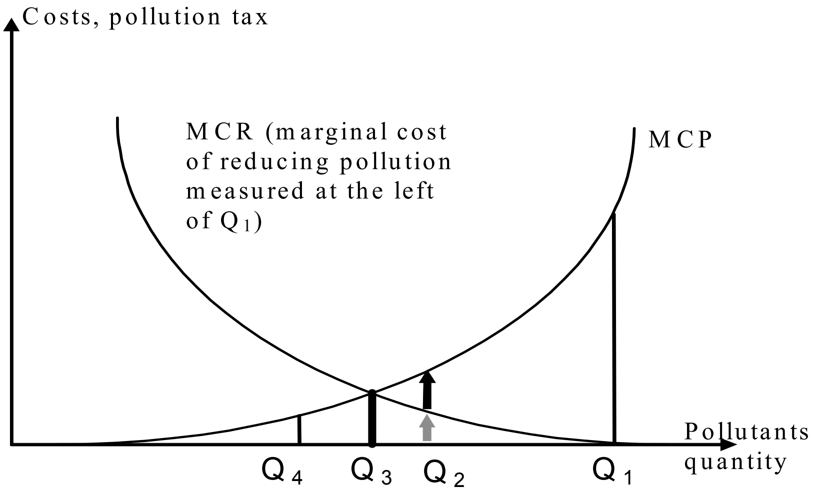

Fig. 4. Loss of efficiency by allowing pollution uncontrolled

IV. CONCLUSIONS

In conclusion, it seems that the best objective, Q_3, can be found only by taking into account both the cost of allowing pollution, MCP, and the cost of removing it, MCR.

Unfortunately, in practice is not so easy to estimate the objective Q_3 due to the difficulties in estimating MCP and MCR. For example, in an attempt to estimate the marginal cost of pollution MCP, we do not know precisely how dangerous pollutants are actually. Moreover, there are many pollutants and the damage it produces each may depend on the presence of the others.

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