The economic common sense of pollution

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We are going to make very little real progress in solving the problem of pollution until we recognize it for what, primarily, it is: an economic problem, which must be understood in economic terms. Of course, there are noneconomic aspects of pollution, as there are with all economic problems, but all too often, such secondary matters dominate discussion. Engineers, for example, are certain that pollution will vanish once they find the magic gadget or power source. Politicians keep trying to find the right kind of bureaucracy; and bureaucrats maintain an unending search for the correct set of rules and regulations. Those who are above such vulgar pursuits pin their hopes on a moral regeneration or social revolution, apparently in the belief that saints and socialists have no garbage to dispose of. But as important as technology, politics, law, and ethics are to the pollution question, all such approaches are bound to have disappointing results, for they ignore the primary fact that pollution is an economic problem.

Before developing an economic analysis of pollution, however, it is necessary to dispose of some popular myths.

First, pollution is not new. Spanish explorers landing in the sixteenth century noted that smoke from Indian campfires hung in the air of the Los Angeles basin, trapped by what is now called the inversion layer. Before the first century B.C., the drinking waters of Rome were becoming polluted.

Second, most pollution is not due to affluence, despite the current
popularity of this notion. In India, the pollution runs in the streets, and advice against drinking the water in exotic lands is often well taken. Nor can pollution be blamed on the self-seeking activities of greedy capitalists. Once-beautiful rivers and lakes which are now open sewers and cesspools can be found in the Soviet Union as well as in the United States, and some of the world’s dirtiest air hangs over cities in Eastern Europe, which are neither capitalist nor affluent. In many ways, indeed, it is much more difficult to do anything about pollution in noncapitalist societies. In the Soviet Union, there is no way for the public to become outraged or to exert any pressure, and the polluters and the courts there work for the same people, who often decide that clean air and water, like good clothing, are low on their list of social priorities.

In fact, it seems probable that affluence, technology, and slow-moving, inefficient democracy will turn out to be the cure more than the cause of pollution. After all, only an affluent, technological society can afford such luxuries as moon trips, three-day weekends, and clean water, although even our society may not be able to afford them all; and only in a democracy can the people hope to have any real influence on the choice among such alternatives.

What is new about pollution is what might be called the problem of pollution. Many unpleasant phenomena—poverty, genetic defects, hurricanes—have existed forever without being considered problems; they are, or were, considered to be facts of life, like gravity and death, and a mature person simply adjusted to them. Such phenomena become problems only when it begins to appear that something can and should be done about them. It is evident that pollution has advanced to the problem stage. Now the question is what can and should be done?

Most discussions of the pollution problem begin with some startling facts: Did you know that 15,000 tons of filth are dumped into the air of Los Angeles County every day? But by themselves, such facts are meaningless, if only because there is no way to know whether 15,000 tons is a lot or a little. It is much more important for clear thinking about the pollution problem to understand a few economic concepts than to learn a lot of sensational-sounding numbers.

Marginalism

One of the most fundamental economic ideas is that of marginalism, which entered economic theory when economists became aware of the differential calculus in the 19th century and used it to formulate economic problems as problems of “maximization.” The standard economic problem came to be viewed as that of finding a level of operation of some activity which would maximize the net
gain from that activity, where the net gain is the difference between the benefits and the costs of the activity. As the level of activity increases, both benefits and costs will increase; but because of diminishing returns, costs will increase faster than benefits. When a certain level of the activity is reached, any further expansion increases costs more than benefits. At this “optimal” level, “marginal cost”—or the cost of expanding the activity—equals “marginal benefit,” or the benefit from expanding the activity. Further expansion would cost more than it is worth, and reduction in the activity would reduce benefits more than it would save costs. The net gain from the activity is said to be maximized at this point.

This principle is so simple that it is almost embarrassing to admit it is the cornerstone of economics. Yet intelligent men often ignore it in discussion of public issues. Educators, for example, often suggest that, if it is better to be literate than illiterate, there is no logical stopping point in supporting education. Or scientists have pointed out that the benefits derived from “science” obviously exceed the costs and then have proceeded to infer that their particular project should be supported. The correct comparison, of course, is between additional benefits created by the proposed activity and the additional costs incurred.

The application of marginalism to questions of pollution is simple enough conceptually. The difficult part lies in estimating the cost and benefits functions, a question to which I shall return. But several important qualitative points can be made immediately. The first is that the choice facing a rational society is not between clean air and dirty air, or between clear water and polluted water, but rather between various levels of dirt and pollution. The aim must be to find that level of pollution abatement where the costs of further abatement begin to exceed the benefits.

The second point is that the optimal combination of pollution control methods is going to be a very complex affair. Such steps as demanding a 10 per cent reduction in pollution from all sources, without considering the relative difficulties and costs of the reduction, will certainly be an inefficient approach. Where it is less costly to reduce pollution, we want a greater reduction, to a point where an additional dollar spent on control anywhere yields the same reduction in pollution levels.

**Markets, efficiency, and equity**

A second basic economic concept is the idea—or the ideal—of the self-regulating economic system. Adam Smith illustrated this ideal with the example of bread in London: the uncoordinated, selfish actions of many people—farmer, miller, shipper, baker, grocer—provide bread for the city dweller, without any central control and at
the lowest possible cost. Pure self-interest, guided only by the famous "invisible hand" of competition, organizes the economy efficiently.

The logical basis of this rather startling result is that, under certain conditions, competitive prices convey all the information necessary for making the optimal decision. A builder trying to decide whether to use brick or concrete will weigh his requirements and tastes against the prices of the materials. Other users will do the same, with the result that those whose needs and preferences for brick are relatively the strongest will get brick. Further, profit-maximizing producers will weigh relative production costs, reflecting society's productive capabilities, against relative prices, reflecting society's tastes and desires, when deciding how much of each good to produce. The end result is that users get brick and cement in quantities and proportions that reflect their individual tastes and society's production opportunities. No other solution would be better from the standpoint of all the individuals concerned.

This suggests what it is that makes pollution different. The efficiency of competitive markets depends on the identity of private costs and social costs. As long as the brick-cement producer must compensate somebody for every cost imposed by his production, his profit-maximizing decisions about how much to produce, and how, will also be socially efficient decisions. Thus, if a producer dumps wastes into the air, river, or ocean; if he pays nothing for such dumping; and if the disposed wastes have no noticeable effect on anyone else, living or still unborn; then the private and social costs of disposal are identical and nil, and the producer's private decisions are socially efficient. But if these wastes do affect others, then the social costs of waste disposal are not zero. Private and social costs diverge, and private profit-maximizing decisions are not socially efficient. Suppose, for example, that cement production dumps large quantities of dust into the air, which damages neighbors, and that the brick-cement producer pays these neighbors nothing. In the social sense, cement will be over-produced relative to brick and other products because users of the products will make decisions based on market prices which do not reflect true social costs. They will use cement when they should use brick, or when they should not build at all.

This divergence between private and social costs is the fundamental cause of pollution of all types, and it arises in any society where decisions are at all decentralized—which is to say, in any economy of any size which hopes to function at all. Even the socialist manager of the brick-cement plant, told to maximize output given the resources at his disposal, will use the People's Air to dispose of the People's Wastes; to do otherwise would be to violate his instructions. And if instructed to avoid pollution "when possible," he does not know what to do: how can he decide whether more brick or cleaner air is more important for building socialism? The capitalist manager is in exactly
the same situation. Without prices to convey the needed information, he does not know what action is in the public interest, and certainly would have no incentive to act correctly even if he did know.

Although markets fail to perform efficiently when private and social costs diverge, this does not imply that there is some inherent flaw in the idea of acting on self-interest in response to market prices. Decisions based on private cost calculations are typically correct from a social point of view; and even when they are not quite correct, it often is better to accept this inefficiency than to turn to some alternative decision mechanism, which may be worse. Even the modern economic theory of socialism is based on the high correlation between managerial self-interest and public good. There is no point in trying to find something—some omniscient and omnipotent *deus ex machina*—to replace markets and self-interest. Usually it is preferable to modify existing institutions, where necessary, to make private and social interest coincide.

And there is a third relevant economic concept: the fundamental distinction between questions of efficiency and questions of equity or fairness. A situation is said to be efficient if it is not possible to rearrange things so as to benefit one person without harming any others. That is the *economic* equation for efficiency. *Politically*, this equation can be solved in various ways; though most reasonable men will agree that efficiency is a good thing, they will rarely agree about which of the many possible efficient states, each with a different distribution of "welfare" among individuals, is the best one. Economics itself has nothing to say about which efficient state is the best. That decision is a matter of personal and philosophical values, and ultimately must be decided by some political process. Economics can suggest ways of achieving efficient states, and can try to describe the equity considerations involved in any suggested social policy; but the final decisions about matters of "fairness" or "justice" cannot be decided on economic grounds.

**Estimating the costs of pollution**

Both in theory and practice, the most difficult part of an economic approach to pollution is the measurement of the cost and benefits of its abatement. Only a small fraction of the costs of pollution can be estimated straightforwardly. If, for example, smog reduces the life of automobile tires by 10 per cent, one component of the cost of smog is 10 per cent of tire expenditures. It has been estimated that, in a moderately polluted area of New York City, filthy air imposes extra costs for painting, washing, laundry, etc., of $200 per person per year. Such costs must be included in any calculation of the benefits of pollution abatement, and yet they are only a part of the relevant costs—and often a small part. Accordingly it rarely is possible to
justify a measure like river pollution control solely on the basis of costs to individuals or firms of treating water because it usually is cheaper to process only the water that is actually used for industrial or municipal purposes, and to ignore the river itself.

The costs of pollution that cannot be measured so easily are often called "intangible" or "noneconomic," although neither term is particularly appropriate. Many of these costs are as tangible as burning eyes or a dead fish, and all such costs are relevant to a valid economic analysis. Let us therefore call these costs "nonpecuniary."

The only real difference between nonpecuniary costs and the other kind lies in the difficulty of estimating them. If pollution in Los Angeles harbor is reducing marine life, this imposes costs on society. The cost of reducing commercial fishing could be estimated directly: it would be the fixed cost of converting men and equipment from fishing to an alternative occupation, plus the difference between what they earned in fishing and what they earn in the new occupation, plus the loss to consumers who must eat chicken instead of fish. But there are other, less straightforward costs: the loss of recreation opportunities for children and sportfishermen and of research facilities for marine biologists, etc. Such costs are obviously difficult to measure and may be very large indeed; but just as surely as they are not zero, so too are they not infinite. Those who call for immediate action and damn the cost, merely because the spiny starfish and furry crab populations are shrinking, are putting an infinite marginal value on these creatures. This strikes a disinterested observer as an overestimate.

The above comments may seem crass and insensitive to those who, like one angry letter-writer to the Los Angeles Times, want to ask: "If conservation is not for its own sake, then what in the world is it for?" Well, what is the purpose of pollution control? Is it for its own sake? Of course not. If we answer that it is to make the air and water clean and quiet, then the question arises: what is the purpose of clean air and water? If the answer is, to please the nature gods, then it must be conceded that all pollution must cease immediately because the cost of angering the gods is presumably infinite. But if the answer is that the purpose of clean air and water is to further human enjoyment of life on this planet, then we are faced with the economists' basic question: given the limited alternatives that a niggardly nature allows, how can we best further human enjoyment of life? And the answer is, by making intelligent marginal decisions on the basis of costs and benefits. Pollution control is for lots of things: breathing comfortably, enjoying mountains, swimming in water, for health, beauty, and the general delectation. But so are many other things, like good food and wine, comfortable housing and fast transportation. The question is not which of these desirable things we should have, but rather what combination is most desirable. To de-
termine such a combination, we must know the rate at which individuals are willing to substitute more of one desirable thing for less of another desirable thing. Prices are one way of determining those rates.

But if we cannot directly observe market prices for many of the costs of pollution, we must find another way to proceed. One possibility is to infer the costs from other prices, just as we infer the value of an ocean view from real estate prices. In principle, one could estimate the value people put on clean air and beaches by observing how much more they are willing to pay for property in nonpolluted areas. Such information could be obtained; but there is little of it available at present.

Another possible way of estimating the costs of pollution is to ask people how much they would be willing to pay to have pollution reduced. A resident of Pasadena might be willing to pay $100 a year to have smog reduced 10 or 20 per cent. In Barstow, where the marginal cost of smog is much less, a resident might not pay $10 a year to have smog reduced 10 per cent. If we knew how much it was worth to everybody, we could add up these amounts and obtain an estimate of the cost of a marginal amount of pollution. The difficulty, of course, is that there is no way of guaranteeing truthful responses. Your response to the question, how much is pollution costing you, obviously will depend on what you think will be done with this information. If you think you will be compensated for these costs, you will make a generous estimate; if you think that you will be charged for the control in proportion to these costs, you will make a small estimate.

In such cases it becomes very important how the questions are asked. For example, the voters could be asked a question of the form: Would you like to see pollution reduced x per cent if the result is a y per cent increase in the cost of living? Presumably a set of questions of this form could be used to estimate the costs of pollution, including the so-called "unmeasurable" costs. But great care must be taken in formulating the questions. For one thing, if the voters will benefit differentially from the activity, the questions should be asked in a way which reflects this fact. If, for example, the issue is cleaning up a river, residents near the river will be willing to pay more for the cleanup and should have a means of expressing this. Ultimately, some such political procedure probably will be necessary, at least until our more direct measurement techniques are greatly improved.

Let us assume that, somehow, we have made an estimate of the social cost function for pollution, including the marginal cost associated with various pollution levels. We now need an estimate of the benefits of pollution—or, if you prefer, of the costs of pollution abatement. So we set the Pollution Control Board (PCB) to work on this task.
The PCB has a staff of engineers and technicians, and they begin working on the obvious question: for each pollution source, how much would it cost to reduce pollution by 10 per cent, 20 per cent, and so on. If the PCB has some economists, they will know that the cost of reducing total pollution by 10 per cent is not the total cost of reducing each pollution source by 10 per cent. Rather, they will use the equimarginal principle and find the pattern of control such that an additional dollar spent on control of any pollution source yields the same reduction. This will minimize the cost of achieving any given level of abatement. In this way the PCB can generate a "cost of abatement" function, and the corresponding marginal cost function.

While this procedure seems straightforward enough, the practical difficulties are tremendous. The amount of information needed by the PCB is staggering; to do this job right, the PCB would have to know as much about each plant as the operators of the plant themselves. The cost of gathering these data is obviously prohibitive, and, since marginal principles apply to data collection too, the PCB would have to stop short of complete information, trading off the resulting loss in efficient control against the cost of better information. Of course, just as fast as the PCB obtained the data, a technological change would make it obsolete.

The PCB would have to face a further complication. It would not be correct simply to determine how to control existing pollution sources given their existing locations and production methods. Although this is almost certainly what the PCB would do, the resulting cost functions will overstate the true social cost of control. Muzzling existing plants is only one method of control. Plants can move, or switch to a new process, or even to a new product. Consumers can switch to a less-polluting substitute. There are any number of alternatives, and the poor PCB engineers can never know them all. This could lead to some costly mistakes. For example, the PCB may correctly conclude that the cost of installing effective dust control at the cement plant is very high and hence may allow the pollution to continue, when the best solution is for the cement plant to switch to brick production while a plant in the desert switches from brick to cement. The PCB can never have all this information and therefore is doomed to inefficiency, sometimes an inefficiency of large proportions.

Once cost and benefit functions are known, the PCB should choose a level of abatement that maximizes net gain. This occurs where the marginal cost of further abatement just equals the marginal benefit. If, for example, we could reduce pollution damages by $2 million at a cost of $1 million, we should obviously impose that $1 million cost. But if the damage reduction is only $1/2 million, we should not and in fact should reduce control efforts.
This principle is obvious enough but is often overlooked. One author, for example, has written that the national cost of air pollution is $11 billion a year but that we are spending less than $50 million a year on control; he infers from this that "we could justify a tremendous strengthening of control efforts on purely economic grounds." That sounds reasonable, if all you care about are sounds. But what is the logical content of the statement? Does it imply we should spend $11 billion on control just to make things even? Suppose we were spending $11 billion on control and thereby succeeded in reducing pollution costs to $50 million. Would this imply we were spending too much on control? Of course not. We must compare the marginal decrease in pollution costs to the marginal increase in abatement costs.

**Difficult decisions**

Once the optimal pollution level is determined, all that is necessary is for the PCB to enforce the pattern of controls which it has determined to be optimal. (Of course, this pattern will not really be the best one, because the PCB will not have all the information it should have.) But now a new problem arises: how should the controls be enforced?

The most direct and widely used method is in many ways the least efficient: direct regulation. The PCB can decide what each polluter must do to reduce pollution and then simply require that action under penalty of law. But this approach has many shortcomings. The polluters have little incentive to install the required devices or to keep them operating properly. Constant inspection is therefore necessary. Once the polluter has complied with the letter of the law, he has no incentive to find better methods of pollution reduction. Direct control of this sort has a long history of inadequacy; the necessary bureaucracies rarely manifest much vigor, imagination, or devotion to the public interest. Still, in some situations there may be no alternative.

A slightly better method of control is for the PCB to set an acceptable level of pollution for each source and let the polluters find the cheapest means of achieving this level. This reduces the amount of information the PCB needs, but not by much. The setting of the acceptable levels becomes a matter for negotiation, political pull, or even graft. As new plants are built and new control methods invented, the limits should be changed; but if they are, the incentive to find new designs and new techniques is reduced.

A third possibility is to subsidize the reduction of pollution, either by subsidizing control equipment or by paying for the reduction of pollution below standard levels. This alternative has all the problems of the above methods, plus the classic shortcoming which
plagues agricultural subsidies: the old joke about getting into the
not-growing-cotton business is not always so funny.

The PCB will also have to face the related problem of deciding
who is going to pay the costs of abatement. Ultimately, this is a
question of equity or fairness which economics cannot answer; but
economics can suggest ways of achieving equity without causing
inefficiency. In general, the economist will say: if you think polluter
A is deserving of more income at polluter B's expense, then by all
means give A some of B's income; but do not try to help A by
allowing him to pollute freely. For example, suppose A and B each
operate plants which produce identical amounts of pollution. Be-
cause of different technologies, however, A can reduce his pollution
10 per cent for $100, while B can reduce his pollution 10 per cent
for $1,000. Suppose your goal is to reduce total pollution 5 per cent.
Surely it is obvious that the best (most efficient) way to do this is
for A to reduce his pollution 10 per cent while B does nothing. But
suppose B is rich and A is poor. Then many would demand that B
reduce his pollution 10 per cent while A does nothing because B has
a greater "ability to pay." Well, perhaps B does have greater ability
to pay, and perhaps it is "fairer" that he pay the costs of pollution
control; but if so, B should pay the $100 necessary to reduce A's pol-
lution. To force B to reduce his own pollution 10 per cent is equivalent
to taxing B $1,000 and then blowing the $1,000 on an extremely in-
efficient pollution control method. Put this way, it is obviously a
stupid thing to do; but put in terms of B's greater ability to pay, it
will get considerable support though it is no less stupid. The more
efficient alternative is not always available, in which case it may be
acceptable to use the inefficient method. Still, it should not be the
responsibility of the pollution authorities to change the distribution
of welfare in society; this is the responsibility of higher authorities.
The PCB should concentrate on achieving economic efficiency with-
out being grossly unfair in its allocation of costs.

Clearly, the PCB has a big job which it will never be able to handle
with any degree of efficiency. Some sort of self-regulating system,
like a market is needed, which will automatically adapt to changes
in conditions, provide incentives for development and adoption of
improved control methods, reduce the amount of information the
PCB must gather and the amount of detailed control it must exercise,
and so on. This, by any standard, is a tall order.

Putting a price on pollution

And yet there is a very simple way to accomplish all this. Put a
price on pollution. A price-based control mechanism would differ
from an ordinary market transaction system only in that the PCB
would set the prices, instead of their being set by demand-supply
forces, and that the state would force payment. Under such a system, anyone could emit any amount of pollution so long as he pays the price which the PCB sets to approximate the marginal social cost of pollution. Under this circumstance, private decisions based on self-interest are efficient. If pollution consists of many components, each with its own social cost, there should be different prices for each component. Thus, extremely dangerous materials must have an extremely high price, perhaps stated in terms of "years in jail" rather than "dollars," although a sufficiently high dollar price is essentially the same thing. In principle, the prices should vary with geographical location, season of the year, direction of the wind, and even day of the week, although the cost of too many variations may preclude such fine distinctions.

Once the prices are set, polluters can adjust to them any way they choose. Because they act on self-interest they will reduce their pollution by every means possible up to the point where further reduction would cost more than the price. Because all face the same price for the same type of pollution, the marginal cost of abatement is the same everywhere. If there are economies of scale in pollution control, as in some types of liquid waste treatment, plants can cooperate in establishing joint treatment facilities. In fact, some enterprising individual could buy these wastes from various plants (at negative prices—i.e., they would get paid for carting them off), treat them, and then sell them at a higher price, making a profit in the process. (After all, this is what rubbish removal firms do now.) If economies of scale are so substantial that the provider of such a service becomes a monopolist, then the PCB can operate the facilities itself.

Obviously, such a scheme does not eliminate the need for the PCB. The board must measure the output of pollution from all sources, collect the fees, and so on. But it does not need to know anything about any plant except its total emission of pollution. It does not control, negotiate, threaten, or grant favors. It does not destroy incentive because development of new control methods will reduce pollution payments.

As a test of this price system of control, let us consider how well it would work when applied to automobile pollution, a problem for which direct control is usually considered the only feasible approach. If the price system can work here, it can work anywhere.

Suppose, then, that a price is put on the emissions of automobiles. Obviously, continuous metering of such emissions is impossible. But it should be easy to determine the average output of pollution for cars of different makes, models, and years, having different types of control devices and using different types of fuel. Through graduated registration fees and fuel taxes, each car owner would be assessed roughly the social cost of his car's pollution, adjusted for whatever control devices he has chosen to install and for his driving habits.
If the cost of installing a device, driving a different car, or finding alternative means of transportation is less than the price he must pay to continue his pollution, he will presumably take the necessary steps. But each individual remains free to find the best adjustment to his particular situation. It would be remarkable if everyone decided to install the same devices which some states currently require; and yet that is the effective assumption of such requirements.

Even in the difficult case of auto pollution, the price system has a number of advantages. Why should a person living in the Mojave desert, where pollution has little social cost, take the same pains to reduce air pollution as a person living in Pasadena? Present California law, for example, makes no distinction between such areas; the price system would. And what incentive is there for auto manufacturers to design a less polluting engine? The law says only that they must install a certain device in every car. If GM develops a more efficient engine, the law will eventually be changed to require this engine on all cars, raising costs and reducing sales. But will such development take place? No collusion is needed for manufacturers to decide unanimously that it would be foolish to devote funds to such development. But with a pollution fee paid by the consumer, there is a real advantage for any firm to be first with a better engine, and even a collusive agreement wouldn’t last long in the face of such an incentive. The same is true of fuel manufacturers, who now have no real incentive to look for better fuels. Perhaps most important of all, the present situation provides no real way of determining whether it is cheaper to reduce pollution by muzzling cars or industrial plants. The experts say that most smog comes from cars; but even if true, this does not imply that it is more efficient to control autos rather than other pollution sources. How can we decide which is more efficient without mountains of information? The answer is, by making drivers and plants pay the same price for the same pollution, and letting self-interest do the job.

In situations where pollution outputs can be measured more or less directly (unlike the automobile pollution case), the price system is clearly superior to direct control. A study of possible control methods in the Delaware estuary, for example, estimated that, compared to a direct control scheme requiring each polluter to reduce his pollution by a fixed percentage, an effluent charge which would achieve the same level of pollution abatement would be only half as costly—a saving of about $150 million. Such a price system would also provide incentive for further improvements, a simple method of handling new plants, and revenue for the control authority.

In general, the price system allocates costs in a manner which is at least superficially fair: those who produce and consume goods which cause pollution, pay the costs. But the superior efficiency in control and apparent fairness are not the only advantages of the
price mechanism. Equally important is the ease with which it can be put into operation. It is not necessary to have detailed information about all the techniques of pollution reduction, or estimates of all costs and benefits. Nor is it necessary to determine whom to blame or who should pay. All that is needed is a mechanism for estimating, if only roughly at first, the pollution output of all polluters, together with a means of collecting fees. Then we can simply pick a price—any price—for each category of pollution, and we are in business. The initial price should be chosen on the basis of some estimate of its effects but need not be the optimal one. If the resulting reduction in pollution is not "enough," the price can be raised until there is sufficient reduction. A change in technology, number of plants, or whatever, can be accommodated by a change in the price, even without detailed knowledge of all the technological and economic data. Further, once the idea is explained, the price system is much more likely to be politically acceptable than some method of direct control. Paying for a service, such as garbage disposal, is a well-established tradition, and is much less objectionable than having a bureaucrat nosing around and giving arbitrary orders. When businessmen, consumers, and politicians understand the alternatives, the price system will seem very attractive indeed.

Who sets the prices?

An important part of this method of control obviously is the mechanism that sets and changes the pollution price. Ideally, the PCB could choose this price on the basis of an estimate of the benefits and costs involved, in effect imitating the impersonal workings of ordinary market forces. But because many of the costs and benefits cannot be measured, a less "objective," more political procedure is needed. This political procedure could take the form of a referendum, in which the PCB would present to the voters alternative schedules of pollution prices, together with the estimated effects of each. There would be a massive propaganda campaign waged by the interested parties, of course. Slogans such as "Vote NO on 12 and Save Your Job," or "Proposition 12 Means Higher Prices," might be overstatements but would contain some truth, as the individual voter would realize when he considered the suggested increase in gasoline taxes and auto registration fees. But the other side, in true American fashion, would respond by overstating their case: "Smog Kills, Yes on 12," or "Stop Them From Ruining Your Water." It would be up to the PCB to inform the public about the true effects of the alternatives; but ultimately, the voters would make the decision.

It is fashionable in intellectual circles to object to such democratic procedures on the ground that the uncultured masses will not make correct decisions. If this view is based on the fact that the technical
and economic arguments are likely to be too complex to be decided by direct referendum, it is certainly a reasonable position; one obvious solution is to set up an elective or appointive board to make the detailed decisions, with the expert board members being ultimately responsible to the voters. But often there is another aspect to the antidemocratic position—a feeling that it is impossible to convince the people of the desirability of some social policy, not because the issues are too complex but purely because their values are "different" and inferior. To put it bluntly: many ardent foes of pollution are not so certain that popular opinion is really behind them, and they therefore prefer a more bureaucratic and less political solution.

The question of who should make decisions for whom, or whose desires should count in a society, is essentially a noneconomic question that an economist cannot answer with authority, whatever his personal views on the matter. The political structures outlined here, when combined with the economic suggestions, can lead to a reasonably efficient solution of the pollution problem in a society where the tastes and values of all men are given some consideration. In such a society, when any nonrepresentative group is in a position to impose its particular evaluation of the costs and benefits, an inefficient situation will result. The swimmer or tidepool enthusiast who wants Los Angeles Harbor converted into a crystal-clear swimming pool, at the expense of all the workers, consumers, and businessmen who use the harbor for commerce and industry, is indistinguishable from the stockholder in Union Oil who wants maximum output from offshore wells, at the expense of everyone in the Santa Barbara area. Both are urging an inefficient use of society's resources; both are trying to get others to subsidize their particular thing—a perfectly normal, if not especially noble, endeavor.

If the democratic principle upon which the above political suggestions are based is rejected, the economist cannot object. He will still suggest the price system as a tool for controlling pollution. With any method of decision—whether popular vote, representative democracy, consultation with the nature gods, or a dictate of the intellectual elite—the price system can simplify control and reduce the amount of information needed for decisions. It provides an efficient, comprehensive, easily understood, adaptable, and reasonably fair way of handling the problem. It is ultimately the only way the problem will be solved. Arbitrary, piecemeal, stop-and-go programs of direct control have not and will not accomplish the job.

Some objections aren't an answer

There are some objections that can be raised against the price system as a tool of pollution policy. Most are either illogical or apply with much greater force to any other method of control.
For example, one could object that what has been suggested here ignores the difficulties caused by fragmented political jurisdictions; but this is true for any method of control. The relevant question is: what method of control makes interjurisdictional cooperation easier and more likely? And the answer is: a price system, for several reasons. First, it is probably easier to get agreement on a simple schedule of pollution prices than on a complex set of detailed regulations. Second, a uniform price schedule would make it more difficult for any member of the "cooperative" group to attract industry from the other areas by promising a more lenient attitude toward pollution. Third, and most important, a price system generates revenues for the control board, which can be distributed to the various political entities. While the allocation of these revenues would involve some vigorous discussion, any alternative methods of control would require the various governments to raise taxes to pay the costs, a much less appealing prospect; in fact, there would be a danger that the pollution prices might be considered a device to generate revenue rather than to reduce pollution, which could lead to an overly-clean, inefficient situation.

Another objection is that the Pollution Control Board might be captured by those it is supposed to control. This danger can be countered by having the board members subject to election or by having the pollution prices set by referendum. With any other control method, the danger of the captive regulator is much greater. A uniform price is easy for the public to understand, unlike obscure technical arguments about boiler temperatures and the costs of electrostatic collectors versus low-sulfur oil from Indonesia; if pollution is too high, the public can demand higher prices, pure and simple. And the price is the same for all plants, with no excuses. With direct control, acceptable pollution levels are negotiated with each plant separately and in private, with approved delays and special permits and other nonsense. The opportunities for using political influence and simple graft are clearly much larger with direct control.

A different type of objection occasionally has been raised against the price system, based essentially on the fear that it will solve the problem. Pollution, after all, is a hot issue with which to assault The Establishment, Capitalism, Human Nature, and Them; any attempt to remove the issue by some minor change in institutions, well within The System, must be resisted by The Movement. From some points of view, of course, this is a perfectly valid objection. But one is hopeful that there still exists a majority more concerned with finding solutions than with creating issues.

There are other objections which could be raised and answered in a similar way. But the strongest argument for the price system is not found in idle speculation but in the real world, and in particular,
in Germany. The Rhine River in Germany is a dirty stream, recently made notorious when an insecticide spilled into the river and killed millions of fish. One tributary of the Rhine, a river called the Ruhr, is the sewer for one of the world's most concentrated industrial areas. The Ruhr River valley contains 40 per cent of German industry, including 80 per cent of coal, iron, steel and heavy chemical capacity. The Ruhr is a small river, with a low flow of less than half the flow on the Potomac near Washington. The volume of wastes is extremely large—actually exceeding the flow of the river itself in the dry season! Yet people and fish swim in the Ruhr River.

This amazing situation is the result of over forty years of control of the Ruhr and its tributaries by a hierarchy of regional authorities. These authorities have as their goal the maintenance of the quality of the water in the area at minimum cost, and they have explicitly applied the equimarginal principle to accomplish this. Water quality is formally defined in a technological rather than an economic way; the objective is to "not kill the fish." Laboratory tests are conducted to determine what levels of various types of pollution are lethal to fish, and from these figures an index is constructed which measures the "amount of pollution" from each source in terms of its fish-killing capacity. This index is different for each source, because of differences in amount and composition of the waste, and geographical locale. Although this physical index is not really a very precise measure of the real economic cost of the waste, it has the advantage of being easily measured and widely understood. Attempts are made on an ad hoc basis to correct the index if necessary—if, for example, a non-lethal pollutant gives fish an unpleasant taste.

Once the index of pollution is constructed, a price is put on the pollution, and each source is free to adjust its operation any way it chooses. Geographical variation in prices, together with some direct advice from the authorities, encourage new plants to locate where pollution is less damaging. For example, one tributary of the Ruhr has been converted to an open sewer; it has been lined with concrete and landscaped, but otherwise no attempt is made to reduce pollution in the river itself. A treatment plant at the mouth of the river processes all these wastes at low cost. Therefore, the price of pollution on this river is set low. This arrangement, by the way, is a rational, if perhaps unconscious, recognition of marginal principles. The loss caused by destruction of one tributary is rather small, if the nearby rivers are maintained, while the benefit from having this inexpensive means of waste disposal is very large. However, if another river were lost, the cost would be higher and the benefits lower; one open sewer may be the optimal number.

The revenues from the pollution charges are used by the authorities to measure pollution, conduct tests and research, operate dams to regulate stream flow, and operate waste treatment facilities where
economies of scale make this desirable. These facilities are located at the mouths of some tributaries, and at several dams in the Ruhr. If the authorities find pollution levels are getting too high, they simply raise the price, which causes polluters to try to reduce their wastes, and provides increased revenues to use on further treatment. Local governments influence the authorities, which helps to maintain recreation values, at least in certain stretches of the river.

This classic example of water management is obviously not exactly the price system method discussed earlier. There is considerable direct control, and the pollution authorities take a very active role. Price regulation is not used as much as it could be; for example, no attempt is made to vary the price over the season, even though high flow on the Ruhr is more than ten times larger than low flow. If the price of pollution were reduced during high flow periods, plants would have an incentive to regulate their production and/or store their wastes for release during periods when the river can more easily handle them. The difficulty of continuously monitoring wastes means this is not done; as automatic, continuous measurement techniques improve and are made less expensive, the use of variable prices will increase. Though this system is not entirely regulated by the price mechanism, prices are used more here than anywhere else, and the system is much more successful than any other. 1 So, both in theory and in practice, the price system is attractive, and ultimately must be the solution to pollution problems.

"If we can go to the moon, why ... etc?"

"If we can go to the moon, why can't we eliminate pollution?" This new, and already trite, rhetorical question invites a rhetorical response: "If physical scientists and engineers approached their tasks with the same kind of wishful thinking and fuzzy moralizing which characterizes much of the pollution discussion, we would never have gotten off the ground." Solving the pollution problem is no easier than going to the moon, and therefore requires a comparable effort in terms of men and resources and the same sort of logical hard-headedness that made Apollo a success. Social scientists, politicians, and journalists who spend their time trying to find someone to blame, searching for a magic device or regulation, or complaining about human nature, will be as helpful in solving the pollution problem as they were in getting us to the moon. The price system outlined here is no magic formula, but it attacks the problem at its roots, and has a real chance of providing a long-term solution.

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1 For a more complete discussion of the Ruhr Valley system, see Allen V. Kneese, The Economics of Regional Water Quality Management (Baltimore, Md.: Johns Hopkins Press, 1964).