ENVIRONMENTAL ECONOMICS – EMPIRICAL APPROACHES REGULATIONS AND POLICY

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Appraisal of the environment is a very complex concept since there are many interconnections between the environment and socio-economic activity. The environment is viewed traditionally as a source of inputs into the economy, ranging from raw materials like ores and fossil fuels to the supply of goods like water and fish. But the environment also provides other services. It provides life-supporting services that allow us to survive on this planet. Moreover, it provides the opportunity for recreation, the pleasure of enjoying a beautiful environment and the ability to store the residuals that are generated as by-products of economic activity.

Economic agents value goods because they derive utility from the consumption of these goods. The amount of money they are willing to pay for the consumption of a certain good simply reflects how much utility they derive from the consumption of this particular good, relative to the utility they derive from the consumption of other available goods. This means that for goods that are traded freely and efficiently in markets, like the raw materials mentioned above the price of these goods approximates quite accurately the valuation agents have for these goods. It has been shown that the problem with most environmental goods, like life-supporting services and opportunities for recreation, is that, unfortunately, they are usually not traded freely in efficient markets. As a result, more involved methods must be employed to provide some estimate of the valuation economic agents have for these goods.

Since trying to value environmental goods directly is extremely difficult, techniques have been developed to value, instead, the benefit from specific projects that lead to environmental improvements or, alternatively, to value the damage of a specific environmental degradation. The evaluation can: (a) take place before the improvement project is implemented, or (b) assess the risk of a possible environmental degradation. It might also be implemented after an environmental degradation has occurred, for example a damaging incident such as an oil spill or a nuclear accident, in order to estimate the extent and value of the caused damages and to help policy makers decide on measures that will reduce the risks of similar damages occurring in the future.

In most cases the environmental economist is called to recommend on a specific proposed project that aims at a particular environmental improvement or a measure that reduces the risk of certain kinds of accidents that may lead to environmental degradation. The environmental economist is called first to estimate the proposed benefits and the involved costs and then, based on these estimates, to evaluate the results of his analysis and justify his recommendation. Obviously, this task is served very well by those techniques that aim to evaluate the impact of particular projects.

Valuing environmental improvements or the price of degradations

Within the field of environmental economics, the debate has moved on from an issue of delineation to one of measurement. Measurement is a prerequisite to promoting a sustainable society and during the 1990s there has been a boom in programmes with the aim of devising environmental indicators. Environmental economists try to estimate how the benefits that will accrue in the present and in the future are valued. Future benefits are discounted in order to estimate the present value of all expected benefits. They also have to assess the probability of a project that aims at an environmental improvement to succeed, if the outcome of the project is not certain, or to assess the reduction in the probability of an environmentally degrading accident happening, in the case that the programme under examination aims at reducing such risks.

The first method presented provides a direct estimate for the monetary value of the environmental improvement, an environmental degradation or the reduction in the risk of an environmental degradation, which usually is some kind of pollution. The second method presented measures the willingness of the affected agents to pay to acquire a particular environmental good or to reduce the risk of the said degradation.

Direct measure of damages or benefits.

This process usually builds on some theoretical model that uses information taken from markets in order to present an estimate of the value assigned by society to an environmental degradation or improvement. Such a process usually has multiple steps.

- The impact of the proposed project is examined. Both private and public assessments of the environmental impact are submitted. All possible effects, positive and adverse, current and future, are included at this stage.
- The impact of the policy on ambient quality is estimated.
- Human exposure to the affected environment is estimated.
- The human exposure to the change in ambient quality is valued.

In many cases, the process is complemented by further steps.

- The economic impact of the project, the cost to individuals and society, as well as possible benefits, have to be assessed.
- The impact of necessary regulations is assessed.
- Cost-effectiveness analysis takes the goals as given and examines alternative methods of achieving the goals. The cost of these methods and their potential results are taken into account.

An example of this method is the emissions control model. The process in this model starts by measuring the extent of the environmental degradation caused by a certain type of emissions, followed by the impact of the environmental degradation on ambient quality. An estimate of human exposure to the degraded environment comes next. Finally, the impact of exposure to the degraded environment on humans and their activities is determined, and the value of these impacts is measured.

This method generally takes information from markets to assign monetary values on the affected elements, which is a great convenience whenever such information is available. The problem with this method is that the estimates are almost always seriously incomplete. This is not only true because some objective elements will almost certainly be missed, but the method also fails to include an estimate for elements for which there is no available market price, as is often the case with environmental goods. Also it often fails to take into account the fact that humans will take initiative to reduce their exposure to a degraded environment.

An example of cases, in which usually sufficient information is available to use this method with relative success, are accidents that seriously damage the environment. The estimate of both the cost of repairing the damage, which is easily collected at the time the damage is being repaired, and the compensation that is claimed through litigation by those affected give a good estimate of the damage done.

Paying for an environmental improvement or avoiding damage

These methods try to infer the valuation agents have for environmental goods from their willingness to pay to enjoy the environmental good or, alternatively, the amount of compensation they command to accept an environmental degradation. Because there is a large available number of such methods there have been efforts to categorise them. Unfortunately, a consensus on these categorisations does not exist. One simple categorisation applies the term "indirect methods" to methods focusing on characteristics, other than the value itself, that reveal the value agents place on environmental characteristics. On the other hand, "direct methods" are the methods that directly ask agents the valuation they place on environmental characteristics. We recognise all kinds of surveys and questionnaires to be labelled here as direct methods. Even though the categorisation of the methods may change from author to author, the list of methods that is generally employed remains usually unchanged.

Some of the most commonly used methods that do not involve questionnaires and that are used to deduce the valuation agents have for some environmental good are those methods that try to capture the willingness of agents to pay for a certain environmental good. The willingness of agents to pay for this environmental good is then used as a proxy for the value these agents assign to this particular environmental good. Unfortunately this method does not always give accurate estimates and, therefore, great care must be taken when it is used. On the other hand, this method permits the environmental economist to obtain some estimate in cases in which no other estimate can be obtained, and in some cases it has yielded very satisfactory results. Typical examples of these methods include:

1. *Expenditures* agents make to protect themselves from some negative environmental impact. The most common example is the installation of sound-proof windows in houses that are close to a highway.
2. *Difference in wage rates*. The idea behind industrial wage rate studies is that it is possible to compare the wage of two comparable jobs, but where one job is located in an area or industry that implies a diminished environmental quality, like increased pollution. The diminished environmental qualities may also imply health risks, like jobs in a coal mine or near a refinery. The wage in the job that is located in the industry that pollutes and poses a health risk should compensate for the decreased enjoyment from lower environmental quality and higher health risks. The difference in the wage can be used to estimate how much the higher environmental quality and the lower health risk is valued by agents. Alternatively, the wages in two comparable cities can be compared. If these two cities differ only in one environmental attribute, say pollution, the difference in the wages in both cities can be used to estimate how much agents value the lower pollution of the cleaner city. The presumption is that the higher wages in the more polluted city exactly compensate for the extra pollution, so that workers are indifferent between living in the clean city and receiving the lower wage and living in the polluted city and receiving the higher wage.
3. *Housing prices*. Following a similar rationale, the price of a house located in an area without an environmental burden should exceed the price of a comparable house located in an area with a certain environmental burden, by exactly the value agents attribute to that particular environmental burden.
4. *Travel costs*. Economist Herald Hotelling suggested that the cost agents pay to experience an environmental amenity, not only including the cost of travel but also the opportunity cost of the time allocated to travel, gives a proxy for the valuation agents have for this amenity.

The success of using these indirect methods always depends on studying the particular case the researcher faces. It is very common that the researcher has to conduct detective work in order to find possible ways that will permit him to obtain an estimate for the desired valuation and to rule out methods that will lead to erroneous, or seriously incomplete estimates.

Direct methods try to infer the willingness of agents to pay for some environmental characteristic by posing questions. Since the way the survey or referendum is conducted may affect

the given answers, great care has to be taken in the preparation of the survey. The steps involved in conducting such a survey and some of the problems that commonly arise are:

- Identifying and clearly describing the environmental characteristic that is to be evaluated. If the agents that will respond can misinterpret or misunderstand the question, their answers will not convey the desired information.
- Selecting the group of agents that will be asked to respond. The selected agents must be sufficiently informed to be able to answer the questions asked and they should not have an incentive to provide erroneous answers.
- Preparing the questions and deciding upon the method of the survey. Experience has shown that the way the question is formulated can severely affect the answers that are given. Also, the respondents' answers often differ according to whether they are voting in a referendum whose outcome is going to lead directly to specific policy implementation, or whether they are participating in a simple survey that will be used for some general evaluation.
- Aggregating and analysing the results. After collecting the individual responses, the researcher has to decide how to aggregate the data, so that it can be analysed with confidence and convey the desired information.

Regarding these difficulties, experience has shown the conductors of such surveys that taking certain measures can greatly improve the quality of the collected answers. Some of these measures include:

1. Referenda in which agents know that their answers will directly affect the outcome have an advantage over hypothetical surveys, in that they bring agents closer to acting like they would in a market environment. Regardless of the method employed, by constructing two-stage questions agents can be guided to provide more accurate information. The first stage can ask the agent if, generally, they would be willing to pay for an environmental improvement or for the reduction of an environmental degradation. At the second stage, if the first answer was positive, the agents can be asked to indicate, approximately, the amount they would like to pay.
2. Experience has shown that agents answer better to closed-ended questions than to open-ended questions. "Would you prefer a tax that is less than x dollars, or a tax that is more than x dollars" is always more effective than a question of the type "How many dollars would you like the tax to be." A very efficient method for the second stage of referendum questions mentioned above are closed ended questions that allow agents to select among possible ranges, i.e.: "Would you pay more than 1,000 dollars. If no, would you pay more than 500 dollars. If no, would you pay more than 250 dollars." Structuring questions in such a way can make referenda simulate the outcome of a market auction quite accurately.
3. The pertinent information supplied on the subject of interest can be a very important factor. For example, if we seek the valuation agents have for a programme that will save the Northern spotted owl in the United States, the answer from a group of members of the Audubon Society can be expected to differ greatly from the answers obtained by individuals who are unfamiliar with this species. Therefore, care has to be taken to target groups that are truly representative of the attributes that the researcher wants to capture.
4. Poverty and income distribution can be an important factor. Poor workers in an industry that relies on asbestos may say that they do not favour a policy to cut down on asbestos use, out of fear of loosing their jobs, even though they are aware of the health risks of asbestos. If the researcher cannot avoid target groups that demonstrate this problem, he should at least be aware of it and take it into account. Also, surveys that focus on the willingness to pay for an environmental good usually yield different results than surveys that examine the willingness to accept compensation for a reduction in the provided quantity of the environmental good. This is so because the willingness to accept compensation is not constrained by one's income, a possibility that has to be taken into account.
5. Misinformation by the media may lead agents who are targeted by a survey to give different answers than they would if they had proper information. Or a media hype may have shifted attention to a particular environmental characteristic, which therefore offers itself as the subject of a survey, while another, that could be even more important, remains without attention. But even in these cases, the survey can be formulated in such a way that while it focuses on the characteristic that offers itself for the survey, it still yields information on the characteristics that do not offer themselves for the survey.

The evaluation of an environmental project should also include non-use values. Non-use values are the values agents attach to goods they know they will never use or enjoy. For example, someone who knows they will never travel to see a Northern spotted owl still may desire to pay for the preservation of the species. The evaluation of non-use values is usually very difficult and often a problem in the efforts to evaluate environmental projects. For these reasons, specialised models have been developed in some cases; however, they tend to be quite complicated.

Even if we are able to use all these methods, and possibly others, to obtain an estimate for the value agents assign to the benefits of an environmental project, we are still faced with the challenge of estimating possible secondary effects. These are effects that are not thought of in advance and, therefore, their impact is not included in the answers to surveys or reflected in the market data that were used to form an estimate of the value of a particular project. Still, the responsibility remains to search for such possible effects before concluding the estimate of the valuation agents have for the impact of the examined environmental programme.

It is true that it is often difficult to estimate the valuation agents and society as a whole have for environmental goods, especially in the case when these have some aspects of public goods and obvious market prices cannot be readily used. But the case is not always hopeless. However flawed and inaccurate they may sometimes be, the methods mentioned so far allow the researcher to obtain, in most cases, at least an approximate estimate for the valuation sought.

Estimating the cost of avoiding environmental degradation or securing an environmental improvement

Estimating the cost of a programme that will lead to an environmental improvement or help avoid an environmental degradation has its own difficulties. Usually, those that are expected to bear the cost are asked, through a survey, about the costs they expect. But there is always the risk that the surveyed group will overestimate the costs, in order to postpone or cancel the implementation of a measure that is costly to them, or simply to secure higher compensation. Because of these risks, the survey is usually complemented by a technical analysis, written by specialised engineers. These engineers use the data from similar measures that may have been implemented in other cases, and from their knowledge of the current state of the technology and the affected processes, to come up with an estimate of the costs.

The cost of an environmental programme must reflect the total cost that will be paid by society. It has to depart from simply including the cost that is born by those directly affected, which can be a firm or a group of firms. A whole geographical area may need to adapt, in some way, the government may pay subsidies or compensations to some affected individual and local measures may have effects in other areas and impose costs in these areas. Measuring the cost for society as a whole means that all such effects have to be taken into consideration. Possible environmental costs also have to be included. It might sound surprising, but many programmes that aim at environmental improvements often imply some kind of opportunity cost for the environment. For example, industrial waste that is not dumped in the sea any more has to be disposed of otherwise. Regardless of the monetary cost of the alternative disposal, it implies an environmental degradation that may be a less serious environmental degradation but it still is an environmental degradation. Also, many policies that aim at environmental improvements require monitoring and enforcement. These are costs born by society that have to be included in the estimates, especially as these costs often turn out to be significant. Opportunity costs for all of society, as well as political costs or the cost imposed by a change in regulations have to be considered. Finally, many environmental improvements require the construction and maintenance of specialised facilities, like flood control projects, hazardous-waste incinerators and so on. The present value of the construction and the maintenance cost of such facilities certainly have to be included in the cost estimates. And again it is true that the approach selected to estimate the costs of a particular project has to be adapted to the characteristics of the particular project at hand.

Table 1. Estimated cost in thousand dollars to comply with environmental regulations. Metal finishing industry (anodising process).

Number of employees	1-9	10-19	20-49	50+
Number in size	137	65	70	26
Investment costs				
Equipment	46	57	72	264
Building and land	11	17	22	47
Installation	9	12	14	53
Total	66	86	108	364
Annual costs				
Capital costs	3.3	4.3	5.4	18.2
Depreciation	6.6	8.6	10.8	36.4
Labour	12.2	24.1	32.9	105.1
Energy	3.1	5.2	7.4	14.1
Other	8.7	12.3	19.8	28.3
Total	33.9	54.5	76.3	202.1

Source adapted from U.S. E.P.A. Economic analysis of effluent guidelines. The metal finishing industry. E.P.A. 230 1-74 032 Washington D.C. September 1974.

The metal finishing industry provides services to major industries that use components made of metals that need special treatment to enhance attributes like corrosion resistance. In the early 1970s the E.P.A. (United States Environmental Protection Agency) was charged with estimating the costs to firms in the metal finishing industry of meeting proposed emission reduction goals. In this particular case, like in many others, there were too many firms in the industry to do a study of each firm separately. To complicate matters more, the firms in the

industry varied significantly according to a number of attributes, making it difficult to base estimates of the cost on a model that builds on a representative "average" firm. For that reason, a number of four different representative firms was specified. Costs were estimated for four different firm sizes, where firm size was determined according to the number of employees.

The first section in Table 1 shows the investment costs needed to install new equipment that was going to allow the firms to reduce their emission flows. Then, the annual cost of operating efficiently the equipment over its projected life span is given. This cost includes depreciation of the equipment and the opportunity cost of the invested capital.

By multiplying the total annual cost for each category of firms with the number of firms in each category we can estimate the total annual cost of compliance for the whole industry. Thus the anticipated total annual cost of compliance was estimated to be $13,975,500. Note that this estimate was incomplete, at least in the sense that it did not include the cost of the resources required to enforce large-scale compliance and to monitor the compliance of the regulated firms.

Evaluating the benefits and costs

Having completed the estimate of the valuation society has for the benefits of an environmental project and having conducted a separate estimate of the costs involved with implementing this project, the environmental economist is asked to evaluate the results and to recommend on the proposed project. There are many possible criteria according to which this recommendation can be made. One possible criterion is to select only those projects that optimise the difference between benefits and costs. But, because of the approximate estimates that are usually obtained for the benefits and costs, such a criterion may be difficult to be applied in an reliable manner. Therefore, usually simpler criteria are employed. One common criterion is to promote those projects for which the present value of the benefits exceeds the present value of the costs. Still, there are problems even with using this criterion, as simple changes in the way environmental risks are treated or changes in the discount rates that are used to compute the present value of future flows of benefits and costs can lead to significantly different outcomes.

These vague issues, like the employed valuation of risks and the employed discount rates, have to be given specific answers in a given analysis if the methods proposed are to provide concrete information on which decisions can be based. This should caution the researcher from becoming too overconfident that all answers can be given reliably and without error to all questions. It also means that a not very rigorous, but efficient and quite reliable, criterion is to promote only those projects for which the present value of the anticipated gains significantly exceeds the present value of the projected costs.

Evaluating environmental policy

The theoretical approaches to deal with the problem of externalities and environmental degradation are encouraging in the sense that they prove the problem can be dealt with. It remains to be seen whether those approaches yield efficient results when tested in reality and, if not, which other approaches yield better results. Knowing which approaches yield the most efficient results is very important when environmental policy is designed. Which approaches are finally used is greatly determined by the policies adopted by governments, as governments have the ability to enforce certain rules on economic agents, according to which economic agents will subsequently make their decisions.

Policies can be divided into two comprehensive groups:

- Decentralised policies, that essentially allow individuals to choose themselves the best method to achieve the set objective in a case of environmental protection in which they are directly involved. This group comprises, but is not limited to, market mechanisms.
- Command and control policies. The political authorities dictate by law the behaviour of individuals and use an enforcement and a monitor mechanism to both monitor the behaviour and enforce the desired behaviour on individuals. Command and control methods generally regulate, exactly, the quantity of an environmental good that will be acquired, the amount of pollution that is allowed, or the exact price at which that environmental good or right to pollute is valued.

Decentralised policies usually involve many decision-makers who make their own assessment of the situation at a local level. These local decision-makers usually also have the best access to information that is needed to make the best decisions. Such policies often include:

1. *Common law*. Common law protects those that are suffering damages because of the actions of others. In the United States, the law requires the agent who claims to have suffered damages to prove that the accused polluter has indeed polluted, and then, in a second step, to show that this particular pollution is responsible for the damages. These are quite stringent requirements.
2. *Statutory law*. Governments can enact laws that require polluters to pay some compensation automatically when the pollution is verified, regardless of damages inflicted on any particular individuals. Many countries have used such laws to impose fines on ships that create pollution at sea. These polluters are fined by the enacted laws, regardless of the immediately observable or verified damage the pollution has caused. Such laws make sense in cases where it is difficult to monitor or verify the environmental damage, but which are known to cause significant damage to the environment.
3. *Property rights*. As soon as property rights are specified on an environmental good, the specified owner has an interest in protecting his newly acquired property, and obviously he will use these property rights and the common law to protect the environmental good against any damage. These property rights must have economic value to their owner, in order to provide him with the maximum incentive to protect the environmental good. Therefore, they have to be well defined, enforceable and transferable.

Furthermore, there has to be an efficient market for them and they have to be transferable at a low cost.

4. *Market mechanism*. Broadly speaking, market mechanisms are the mechanisms that permit the market to select, to some degree – the exact extent of which depends on the particular method – the price that is set on an environmental good or permit to pollute, and on the quantity of that good that will be enjoyed or the quantity of pollution that will be permitted. Shifting towards market mechanisms and away from command and control options, most commonly means removing subsidies, quotas and product taxes, implementing emission charges and taxes, defining property rights, introducing tradable permits, encouraging voluntary approaches and promoting the provision of information. According to our loose definition of market mechanisms, any mechanism that allows agents some freedom to choose among an array of ways to comply with emission limits set by regulations on emissions, instead of dictating a particular method to comply with the limit set or a given price for each polluter, can be viewed as a market mechanism.

Command and control policies have one decision-maker in a central administration. He has to gather all the information required to make the necessary decisions that will be executed by his agents at the local level. Such policies include:

1. *Setting ambient standards*. Such standards can be a law dictating that a certain pollutant is tolerated only up to a certain level in drinking water.
2. *Emission standards*. Such standards usually: (a) are set on the rate or concentration of emissions and the total quantity of residuals from a production process, which takes into account both the rate at which the residuals are emitted and the duration of the production process; (b) set a limit on the residuals each produced unit can generate; (c) require a percentage reduction of emissions from their current level, regardless of whether the goal is achieved through a reduction of production or a change in the method of production.
3. *Technology standards*. The application of a particular pollution reduction technology may be required. The issue with these technology standards is how they are set, and how uniformity can be achieved whenever it can lead to significant cost reductions.

Broadly speaking, all mechanisms through which the government aims to control not only the level of emissions but also dictates, precisely, the method with which the desired level of emissions is to be achieved can be labelled a command and control mechanism. As such, quotas, particular subsidies and taxes are often included in this category.

Unfortunately, there is not always a clear distinction between the two groups of policies. Often policies have some aspect that fits the description of decentralised policies and some other aspects that fit the description of command and control policies. But given that for a long period of time most policies had predominantly characteristics that are better described by the definition of command and control technologies, it is common to call decentralised policies those that have at least some characteristics of these policies.

It is not by accident that the Kyoto Protocol signed at the 1997 United Nations Conference on Global Warming permits and encourages countries to co-operate to achieve the goals that have been set, and to use so called market mechanisms. This encouragement is based on the experience gathered so far, mainly in European Union countries and in the U.S.A. from the implementation of market based mechanisms in environmental protection goals. This experience that was gained mainly in the past 10 years broadly sums that market mechanisms make it possible to achieve the set environmental goals at a cost that is at least 10% less than the cost of traditional methods that predominantly have characteristics of command and control policies. The specific gains of market mechanisms are:

1. *Lower cost of compliance*. The polluter is allowed to choose a strategy mix, that includes product changes, changes in inputs or processes, and treatments. Therefore it is more likely that each producer will individually come up with ways to comply that are cheaper than a compliance method that is commanded by a central administrator.
2. *Lower administrative effort and cost*. As markets more or less automatically generate their effects, there are reduced requirements for an expensive bureaucracy that plans and enforces the regulations. Also, the cost of transferring necessary information that is readily available to the markets or local agents to the central bureaucracy can be a time consuming and expensive process.
3. *Introduction of incentives to innovate and improve environmental performance*. One of the main advantages of most market mechanisms is that they provide agents with continuous incentives to innovate, in order to find more cost effective ways to comply with the existing requirements.
4. In some instances, the *generation of funds*. Especially in cases in which the government is short of cash, charging fees for emission permits can be a very attractive option, particularly when compared to solutions that include costs for bureaucracies and subsidies.
5. *Increased flexibility*. The flexibility of market mechanisms is expected to increase as authorities become more familiar with them and gather experience on the gains from allowing greater flexibility. Gains follow because, in a flexible environment, the market can adapt to new realities without the need for the administrator intervening. But this flexibility also bears a risk, that is the possibility that the market generates undesired results.

Cleaner technologies

Gains that can be achieved through international co-operation and by allowing polluters significant freedom to choose the strategy mix with which they will approach the problem of pollution from their operations. In particular, by introducing simple improvements in the production process that are best suited for the particular firm examined, a reduction in pollution is achieved that would be much more expensive to achieve with other methods. It seems unlikely that a central bureaucracy would have been able to secure similar results at a comparable cost.

The Polish fisheries industry uses herring and other fish from the Baltic and North Seas to produce marinated and canned fish. Water pollution by nitrogen, phosphorus and BOD are the main environmental problems. In a project supported by the Danish National Agency for Environmental Protection, cleaner technologies are being introduced at the "Szkuner" fishery in Wladyslawowo.

The practical measures include: (a) better use of raw material, for example, the use of monitoring equipment; (b) installation of equipment for collecting fish trimmings that are as dry as possible in connection with pre-treatment; (c) installation of water-saving equipment and filters for waste water; and, (d) motivation and training of staff and management.

These measures will improve the environmental performance of the factory. In all, water consumption will be reduced by at least 50 per cent and water pollution is reduced by some 75 per cent, while the yield of marketable products is increased by 5 per cent. For an investment of US $ 330,000-500,000 a pay back period of less than a year has been estimated. This corresponds to a cost of US $ 220,000-330,000 for eliminating 1000 tonnes of BOD, when estimates for traditional treatment technologies give an estimate up to US $ 22 million for the cost of reducing BOD by 1000 tonnes.

Significant efforts are being shifted to prevent pollution through altering the production processes. Experience shows that the cost of modifying production processes to reduce waste and emissions during the process cannot only lead to savings for the firm that implements the modification but the cost of such a process is usually less than the cost of reducing emissions after the production process has been completed or to clean up the pollution afterwards.

Waste prevention

This example shows the constructive contributions voluntary efforts can have. The Industrial Successes with Waste Prevention (Prisma) project was initiated in 1988 by the Netherlands Organisation of Technology Assessment (NOTA). The aim was to investigate large-scale prevention of waste and emissions in Dutch industrial companies. The work in the companies was carried out using *waste minimisation opportunity audits*.

Ten companies took part in the project. In these companies, 35 areas of priority were investigated in full detail, resulting in 164 preventive options ranging from minor changes in procedures and installation to drastic innovations in products or processes. At the end of the project period, 45 of these options were already implemented.

Putting the prevention options into practice led to substantial reductions in waste and emissions. Certain good housekeeping measures led to 25-30 per cent reductions in the use of chemicals. In a number of companies, the introduction of technological changes achieved reductions in waste and emissions of 30 to 80 per cent. Occasionally, it was found possible to eliminate a waste flow completely.

A cost benefit analysis of the options implemented yields an attractive picture, with few extremely favourable benefits. At an investment of US$ 1,250 one company has saved approximately US$ 120,000 a year. Of the 45 implemented prevention options, 20 have turned out to be cost saving and 19 neutral in terms of costs. Several indirect benefits were also achieved, including improved product quality and an easier anticipation of future changes in legal norms and regulations.

Experience has shown that providing useful advice and information is received by firms and polluters usually in a very positive manner. Therefore, organisations that diffuse knowledge and increase the awareness of economic agents concerning the environmental problems, while proposing at the same time useful and sensible solutions, can help polluters to achieve significant results with relatively low cost. It is imperative to recognise that large proportions of the active economic population will respond positively to such initiatives, if they are executed carefully and propose solutions that are easy to implement and that have obvious merits. Securing the co-operation of a large number of agents, even if they only adopt simple measures of environmental protection, can yield significant results at a fraction of the cost extensive large-scale programs require.

Command and control instruments still form the majority, mainly because they form the *status-quo* that has been inherited. They where introduced at a time at which confidence in markets was not sufficiently high to permit bureaucracies to trust them. As a result, the mechanisms and physical infrastructure has been largely built around command and control mechanisms. Even though a constant reduction of these instruments in favour of market mechanisms should be expected, the process will be slow, as the investments made in the current bureaucracies and infrastructure make it difficult to discard instantly the current policies.

Of course, there are cases in which the command and control instruments are appropriate. For one, command and control instruments can be made more acceptable if care is taken to avoid serious mistakes at the stage of their design and execution. They can be enriched with attributes that they lack. For example efforts to improve available pollution reduction technologies could be part of a law restricting emissions of a certain type to predetermined levels. And, of course, there are many cases in which certain extreme environmental hazards impose the need of very stringent regulation, or cases in which legislative regulation turns out to be cheaper. For example, a law forbidding the use of asbestos in automobile breaking systems is simple, effective and a relatively cheap way to achieve the desired result. Also, removing command and control instruments may trigger reactions from groups that have vested interests, like subsidies, to retain these command and control instruments.

European Union environmental policy and experience with market mechanisms

The European Community first introduced concern regarding environmental issues in 1972. Since then, the European policy on environmental issues has evolved at impressive rates. The First Environmental Action Programme (1973-1976) aimed at identifying the environmental problems at hand. The Second Environmental Action Programme (1977-1981) aimed at the

reduction of pollution and nuisance, natural resource management, the protection of the environment and international co-operation. The Third Environmental Action Programme (1982-1986) introduced and strived to enforce *the polluter pays principle* (PPP). The Fourth Environmental Action Programme (1987-1992) is expanded in the Single European Act (SEA) and approaches pollution control and the more efficient management of environmental policy issues.

The Single European Act provided the European Commission with a steady legal basis for future initiatives and integrated environmental issues closely into all policies that are adopted in the European Union.

The relevant articles of the Single European Act introduced the following three principles:

- Prevention is better than cure.
- Damage should be rectified at its source.
- The polluter should pay.

These principles complement the following principles that had already been gradually introduced.

- Decisions should be taken at the E.U. level only if there are clear advantages over taking decisions at the national level.
- Economic efficiency and cost-effectiveness are a priority.
- The cost of policy strategies should, to some extent, be carried more by rich states than by poorer states. Even though this principle often contradicts the polluter pays principle, it can be applied whenever deemed appropriate.

The Fifth Environmental Action Programme followed in 1992. This Programme:

- introduced the idea of cost-effective regulation and encouraged cost-benefit analyses
- encouraged the introduction of more efficient and flexible instruments, like market mechanisms
- encouraged the active involvement of all members of society
- chartered a policy of preventing the depletion of resources and protecting the environment from irreparable damage

Generally, it signalled a more serious commitment towards environmental issues and reflected the experience and expertise that had been gained in the past two decades. It also mentioned, for the first time, the issue of sustainable development. The Maastricht treaty that followed in 1993 introduced the principle of sustainable development more formally.

Recognising that differences among the member-states will not allow too close an instrument harmonisation, at least at this stage, the European Commission aims to set general guidelines and requirements, giving the direction on procedures, principles and objectives and then allowing the member states to proceed with the specific implementation.

Market mechanisms

In 1992, the European Commission formally proposed a combined carbon energy tax, as part of a wider strategy to reduce emissions of carbon dioxide and to form a reliable base to raise tax revenue. The subsequent debate had made it apparent by 1994 that the tax, as proposed, would most likely not be approved by the council of ministers. But this debate also showed how difficult it can be to draw guidelines for environmental policy at the level of the European Union, instead of the national level.

There is no mutual agreement among all member states to a common set of rules according to which emission taxes and charges should be set. In an effort to encourage such alignment, the European Commission has produced a guide, *Environmental Taxes and Charges in the Single Market 1997*, that analyses how to best use environmental taxes and charges at a national level and how to maintain consistency with other policies of the E.U., notably those pertaining to the single market.

The mechanism that has been most popular so far in Europe is emission charges and taxes. As a result, Europe has gained extensive experience in this area. Emission charges to water are of long standing in France, Germany and the Netherlands. Air emission charges are more recent but are characteristic of Sweden and other Scandinavian countries. Waste charges operate in Denmark, while the U.K. has introduced a landfill tax. As a result of the long experience gained in this particular type of mechanism, the European Environmental Agency has been able to collect accurate information regarding the effectiveness of different types of charges under different conditions.

The Rhine Contract

Some of the problems faced in the design of mechanisms for the E.U. arise from the fragmentation of jurisdiction among different member states. We proceed with an example that shows how problems can be overcome through voluntary approaches. It also shows how the legal system can help to outline the rights of those that suffer from negative externalities and force the polluters to internalise at least part of the cost they impose on others through the externality

An example is the Rhine Contract which was signed between the Municipality of Rotterdam and a number of polluters of the Rhine, including the German Association of Chemical Industries that represents 600 firms. The contract is to meet certain reductions in toxic emissions by 2010. The baseline was established in 1985 by the Amsterdam-based International Centre for Water Studies, and agreed to by the industry. Co-operation was facilitated by a 1988 finding by the Netherlands Supreme Court against MDPA (Mines de Potasse d'Alsace). In the case, Dutch nursery firms stated that MDPA emissions of chlorides to the Rhine in Alsace, France, were contributing to damaging saltwater pollution in the Netherlands. After 14 years of litigation, the Dutch court made a judgement against MDPA, in spite of the fact that the French company had a valid licence from the French authorities to emit. The case established the principle that trans-frontier polluters could be sued successfully across frontiers, notwithstanding their compliance with the law in their own jurisdiction.

The essential characteristic of the Rhine Contract is the waiver of claims by Rotterdam for damages if the contracts, which are aimed at an overall reduction of 70-90 percent in toxic emissions, are fulfilled. The modes of dispute resolution in the contract vary. Based on periodic monitoring of the river, it seems that the specified objectives will be met.

To summarise, the European Community has formed the legislative framework concerning the objectives and procedures for air quality and water in the pipeline. Already, emission ceilings for air pollutants are planned for all member states. But emissions trading, even though available, has not been realised so far. Even though market mechanisms are still a small fraction of the imposed environmental measures in the European Union, the right framework is being gradually developed, and, in some aspects, it has been largely completed to allow these mechanisms to play a much more important role in the future.

United States environmental policy

The United States has a history of enforcing environmental policies that, when compared to most other states in the world, is very long. Even though some effort was applied to protect water as early as 1899, with the 1899 Water Refuse Act, this aimed rather at keeping waterways navigable rather than at reducing the environmental impact of pollution. Environmental policy, as we understand it today, started taking concrete shape soon after World War II with the 1948 Water Pollution Control Act and the 1955 Air Pollution Control Act. These acts initiated the study into the possible impacts of water and air pollution, which had not been investigated officially at the time. During the mid 1960s, policy was primarily concerned with empowering local and federal authorities to establish emission standards and to develop ambient quality standards, along with empowering authorities to conduct further research programs that were deemed necessary.

The Air Quality Act of 1967 introduced many provisions to expand research on fuels and vehicles. But, most importantly, it required the establishment of air-quality regions, specifying different standards for ambient quality in different regions. It also required states to establish air-quality standards for certain pollutants and to develop programs to attain these standards. In that sense, it signals the shift of policy from simply trying to recognise and quantify environmental programs towards the implementation of policies that aim to establish environmental improvements.

The Clean Air Act Amendments of 1970 and 1977 developed national ambient quality standards, but also regulated further deterioration for particular areas that where cleaner than the national standards. Also in this period, an increased number of emission standards aimed to control common pollutants and technology standards aimed to further reduce emissions and to lead to the employment of the best available control technologies. This differentiation specified separate areas in which no further ambient quality deterioration was permitted and other areas in which some deterioration, up to a specified level, was permitted.

The Federal Water Pollution control policy followed similar steps, evolving from the 1948 Water Pollution Act and its 1956 Amendments – that aimed at recognising the problem and to establish the desired level of water quality – to the 1965 Water Quality Act that required states to set ambient quality standards for interstate water bodies and to implement plans calling for effluence reduction from particular sources. The 1972 Amendments set federal technology based effluence standards and asked for federal enforcement through the granting of discharge permits to polluters. A goal of zero discharges was set for particular pollutants, to be attained in 1985, and large provisions where made to finance the municipal treatment plant program. In the 1977 Amendment, provisions were made to control toxic effluence in addition of conventional effluence that had been the focus of the previous acts. Funding for treatment plants continued to increase, until the 1981 Municipal Wastewater Treatment Construction Grant Amendments that decreased federal funding for treatment plants.

Significant attention has also been given to the formation of a federal policy on toxic and hazardous substances. A significant amount of policies aimed at controlling chemicals used in the production process and in finished consumer products. Other policies aimed at regulating chemical emissions to the air and water, with special provisions made for drinking water. Finally, policies have been introduced that aim to regulate the handling, storage, transportation, treatment and disposal of hazardous waste.

The United States Environmental Protection Agency

The agency that has taken on the task of monitoring and enforcing most of these policies in the United States is the Environmental Protection Agency (E.P.A.). It was founded in 1970 and gave, at the time, environmental issues much needed visibility and political representation. The E.P.A. conducts extensive research to recommend the legislative bodies on the formation of environmental policies. The research work includes estimating the cost of society to comply with new regulations, benefit-cost analysis of particular projects and verifying if a particular product that is possibly linked with environmental hazards can be sold on the market. The agency's responsibilities also include the monitoring of emissions by polluters, to ensure that polluters do not exceed the limits that have been set. Currently, efforts are being made to avoid giving the agency direct control over the technology choices of the polluters. But the polluter that tries to comply with a new environmental regulation usually has to submit to the E.P.A. a compliance plan that specifies one or more methods – permitted by the act that set the standards the polluter tries to meet – to comply with the said standards. Also, the E.P.A. generally keeps records of emission permits and maintains an archive that lists which permits are held by which polluters. Finally, one of the most important ongoing efforts of the E.P.A. is environmental education. The Environmental Education Programme aims to

educate on the current environmental problems and on the best ways to approach them, not only members of government agencies and industry but also schoolchildren and students. The programme aims at creating general awareness of the problems among all bodies of society. It was initiated because it became apparent that, by educating a society on environmental matters, its members will begin to take initiatives on their own and ultimately push for measures that would be extremely costly or even impossible to enforce on an uninformed society.

The experience gathered over all these years and the impact of a long-lasting tradition in designing environmental policy has lead to one of the most advanced frameworks to deal with environmental issues. It is, therefore, of interest to observe shifts in these policies, as they reflect the experience gained over many years in a large country with a long lasting tradition of environmental sensitivities. Recently, for example, current environmental acts have started to reduce federal funding for significant local environmental protection projects, requiring larger local contributions and signalling a willingness to decentralise not only decision making but also the financial burden of environmental protection. Another key policy is the effort the E.P.A. makes not to dictate technology choices to polluters that try to comply with new standards. Also, the United Stated has been very enthusiastic, from the beginning, about incentive based approaches.

Initially, policy makers in the U.S. tried to improve water quality by setting ambient water standards. These standards were supposed to force polluters to reduce the emissions of pollutants and to encourage local authorities to establish treatment plants. But proving that particular polluters were responsible for the degradation of water quality below the set limits was often a difficult process involving sophisticated scientific methods and it proved in many cases to be difficult to establish in court. Therefore, polluters, recognising that the enacted policies could not be easily enforced, practically ignored them. The federal authorities responded by a shift in policy design. In 1972, they amended the Water Quality Act. Polluters received a number of pollution permits. These permits specified the quantity of a pollutant the holder of the permit can emit, as well as the location at which the pollutant can be emitted and the time at which it can be emitted. Discharging any pollutant without a permit was forbidden. Permits were distributed to polluters according to the abatement technology they chose to employ. Polluters were given a wide range of available abatement technologies to choose from. The technology they chose to adopt put them in one of predetermined categories, that faced specified emission standards. Although these policies faced significant obstacles at the first stages of implementation, which in many cases was delayed or mollified because of administrative difficulties, they form one of the main pillars of water pollution control policy today and have provided significant improvements in water ambient quality.

By all means, the environmental policy in the United States has evolved to affect most aspects of economic activity. Currently, the U.S. is estimated by the E.P.A. to be spending about 2.2% of its GDP to comply to federal environmental regulations, which is a large percentage when compared with the corresponding numbers in most other countries in the world. Obviously, such an extensive policy will include some programs that are not successful. Some cost much more than the benefits they generate, while others are extremely successful in generating benefits well in excess of costs.

Of the next three examples, two are among the greatest success stories of the E.P.A. and show how two specific market mechanisms, emissions trading and property rights, can help environmental agencies to achieve their goals efficiently. They also contain one classic example of failure.

Emissions trading – a success story

Among the great success stories is the regulation of SO_2 emissions from power plants through a flexible trading system. Enacted in 1990 by the U.S. Congress to replace the existing command and control system, it has generated annual savings whose low estimates are in the $1-2 billion dollar-a-year range, and up to over $5 billion for higher estimates.

Part of the success has to do with the fact that emissions of SO_2 come from a limited number of sources, that emissions where already regulated and that, therefore, the situation was largely well understood. Marketable permits have been used with success on other occasions in the U.S., like the regulation of nitrogen oxide emissions in Los Angeles. Emissions trading is one of the most significant policy mechanisms it is expected to play an increasly important role in the future. The following guide states the circumstances under which the use of this particular mechanism has been proven to be most successful.

- The pollutant is readily quantifiable and easily measurable.
- The environmental objective is clearly defined, sufficiently stringent to pose a challenge to the regulated parties, and unlikely to be modified for a reasonable period of time.
- A large number of point sources of pollution exist, where the organisations involved are sufficiently large and sophisticated to deal with the contractual requirements of the permit code trade.
- The environmental problem is not tied too closely to the location of the plant, thereby allowing a large number of plants from a wide geographical area to participate in trade.
- Variations exist in abatement costs between plants, thereby providing significant scope for cost savings through permit trading.
- The market is not dominated by one or a small number of plants holding the majority of permits and being in a position to exercise market power.
- A pre-existing institutional basis for regulatory control exists, providing a structure for monitoring and communication.
- A perceived need exists for greater flexibility in regulation so that permit trading can act as a cheaper means of meeting a binding target.
- The use of alternative policy instruments, notably the imposition of taxes or charges, is politically difficult.

The key criteria for policy design are:

- simplicity – the simpler the scheme the more likely it is to succeed
- challenge – the policy has to constitute a real challenge to polluters
- allocation of permits, which is perceived as fair, based in part on historic data and in part on auction by the regulatory industry
- accurate baseline data and reliable accurate monitoring
- duration and certainty, including protection from confiscation or arbitrary modification of value
- allowing permits to be banked, though this may result in a high emission in a subsequent year
- effective enforcement, including strong penalties for evasion and high probability of detection
- compatibility with existing regulatory requirements
- commitment to the system and its objectives by the key policy stakeholders

Emissions trading – the failure

Emission permits also offer one of the classical examples of failure encountered in the U.S. environmental policy. The 1981 Fox River Permits. The local authorities tried to reduce emissions in the Fox River from a small number of polluting plants with the issuing of pollution permits to the polluters, and hoping that, subsequently, they would trade them among themselves providing an incentive for the plants with the lowest abatement cost to introduce pollution reducing technologies. After a few years, no significant reduction in pollution of the Fox River had taken place. Particular attributes of the way the permits were issued are blamed for the failure of the programme.

- The permits were valid only for five years, and no guarantee was given for their renewal. Renewal was to be decided by a special board every five years. But the uncertainty over the issuing of extensions for the permits proved a significant disincentive to potential buyers of these permits.
- Transaction on the permits had to be previously approved by a special board. To get permission to buy permits, a polluter had to establish that he was unable to reduce pollution by employing other technologies for a cost that was less than the price he was going to pay for the permits. Often, potential buyers could not demonstrate that sufficiently. Therefore, transactions on permits where seriously obstructed.
- There were few polluters, concentrated in a relatively small area. Therefore opportunities to trade the permits where few from the beginning.
- The reduction in the pollutants required from the levels before the enactment of the policy were not very large, and often polluters who exceeded the set levels got exemptions.

All the reasons to which the failure of this particular programme is attributed can be related to the guidelines given above for the design of successful permit trading policies.

Property rights – a success story

Another success story, that demonstrates how powerful a tool the assignment of property rights can be is the 1991 Water Bank in California.

In most countries and regions where a large proportion of the water supply is used for irrigation, water is nominally owned by the state, but the farmers have rights to allocations that give them a sort of *de facto* property entitlement. The farmers receive water, either free of charge or at a price substantially below the open market price. As a result, farmers use water at the margin in uses that yield very low value leading to excessive consumption of water.

Such was the situation in California when it established a Water Bank, operated by the State Department of Water Resources. In February 1991, purchases from water sellers were negotiated at a fixed price of $100 per thousand cubic meters. Purchases ceased in April 1991. Approximately 30% of the transferred water was needed for carriage water to provide salt protection in the Sacramento delta. At this price, plus the transportation cost from the delta, the Water Bank sold 488 million cubic meters. Three quarters of the water was sold to urban agencies at a cost, including transportation, of more than $185 per thousand cubic meters. The water was purchased mostly from farmers. 50 percent from irrigation water and 33 percent from exchanging their surface water rights for ground water rights and selling the surface water to the Water Bank. Although there were far fewer purchasers than suppliers, the fixed-price approach eliminated the market power of the purchasers.

The estimated critical needs dropped from 769 million cubic meters before the Water Bank was fully operational to 601 million cubic meters after it started, indicating how responsive to price such needs can be and leading to a substantial decrease in the consumption of water. Also, the transfers generated an estimated net income and employment gain for the economy – as a result of transferring from lower to higher value uses – of $106 million and 3,741 jobs, respectively. However, jobs did move out of the water exporting regions but the gain in the importing regions more than compensated for the loss.

The problem of sustainable development

The delegations of 178 countries met in Rio de Janeiro in June 1992 for the United Nations Conference on Environment and Development, popularly known as the Earth Summit, in a first effort of charting a course of sustainable development for the future global economy. One possible definition of sustainable development, which can prove to be quite vague a concept, is

given in the Brundland Report which states that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The definition of sustainable development is very important, in order to lay out the goals that are to be achieved. If sustainable development implies, simply, that the welfare of future generations is not reduced below the welfare of current generations, this leaves open the possibility that a certain kind of fish is driven to extinction today, as long as future generations receive appropriate compensation. Therefore, it might be appropriate to include in the definition of sustainable development some provision for the protection of the environment and of its resources. Such an approach also has the advantage that, since it is often impossible to know what value future generations will assign to the environment and its resources, our generations will not be encouraged to cause damage that will later prove to be valued higher than initially believed.

The relevant question is if efficiency in all the markets will automatically imply sustainability of economic performance. If this were true, then identifying the cases in which markets fail and externalities are not internalised would be sufficient to secure sustainability. Resources would immediately be used at efficient levels and no irreparable damage would be caused to the environment simply by eliminating market imperfections. Unfortunately the answer to this question is negative. Increasing efficiency does not imply sustainability, even though it usually represents a move towards sustainability.

Allocation of depletable resources over time

Regardless of the efficient allocation of these resources over time, future generations will inherit diminished quantities of these resources and will therefore be, in that aspect, worse off than current generations. It is possible to invest, however, in new technologies that will use ever-diminishing quantities of these resources to produce at least constant amounts of output. But since the future benefits of developing these technologies are discounted and compared with the cost of these technologies, it is not guaranteed that developing these technologies is an efficient choice.

As attention is drawn to these problems, current generations will find, more and more often, that inefficient sacrifices by current generations are asked for, in order to assure the adequate protection of the well-being of generations that will live in the distant future. To share, fairly, the cost of these sacrifices, those that are responsible for environmental degradation and the depletion of resources because they use them should carry the cost of their actions to a larger extent that they currently do.

Assigning property rights

The users of CFCs, which contribute to both global warming and ozone depletion, do not yet always pay a price for the use of the CFCs that reflects the cost it imposes on current and future generations.

Methods used for internalising externalities on environmental goods are also often used to achieve the goal of sustainable development. Assigning property rights to resources that currently have no specified owner, can lead to the reasonable or even significantly reduced use of these resources. For instance, assigning property rights on the elephant population in Africa will give incentives to the beneficiaries of these rights to protect the elephant population from poaching and survival threatening habitat loss. The following example shows how the allocation of property rights and the organisation of a market for a limited number of fishing permits were used to achieve an objective that aims at sustainable development.

In New Zealand, fisheries that traditionally offer open access were being overfished, driving the population of certain species of fish towards extinction. Traditionally, the problem would have been approached either by regulating the catch of each fishing boat, which would lead to the inefficient use of all boats, or by dictating that only a certain number of boats are allowed to remain and administrating a compensation for those fishers whose boats are confiscated. In this case, a new economic incentive approach was adopted. Transferable catch quotas on all fish currently harvested in the fishery were imposed. The revenues derived from an annual fee on these transferable catch quotas were used to buy out fishermen who were willing to forgo any future fishing for the relevant species up to the point at which the existence of all species was secured. A dangerous pressure on a valuable natural resource was relieved and those fishermen who retired did so voluntarily and for a compensation that reflected their personal valuation of their right to use the fishery.

These facts demonstrate that in the search for sustainable development the powerful forces of the market can be used to attain the desired objectives, while, at the same time, the chosen programme largely paid for itself by imposing the costs of the programme on those that made it necessary to implement. With time, the target of sustainable development will require increasingly large sacrifices, to which directly affected interest groups will offer increasing resistance. It will, therefore, become increasingly indispensable to use the powerful forces of the market to achieve the desired results, whenever possible, through the appropriate allocation of property rights and marketable permits. Such a strategy will often be much easier to enforce than insisting on regulating the activities of those that undermine sustainable development through regulations and taxes.

Natural resource economics, energy and the environment

Most of the activities economic agents engage in imply the consumption of energy. As examples we can cite transportation, the viewing of television and the consumption of even the simplest goods, whose production and transportation to the location they are consumed at involves the use of some kind of energy. Besides the impact the consumption of these goods can have directly on the environment, the consumption of energy itself has very important environmental impacts. Some examples include: the impact CO_2 and CH_4 emissions have on climate change and global warming; the acid precipitation invoked from SOx and NOx emissions; air pollution from NOx and particulate emissions; land use of coal mines; water pollution by tankers and drill platforms; and, radioactivity from nuclear waste. The environmental impact of energy depends on the fuel cycle, or the whole process of gathering forms of

energy from nature, converting them to useable forms of energy and then transporting the useable energy to the location it is used. The usual forms of energy used are heat, electricity, radiation, kinetic and chemical.

The aim of natural resource economics, of which energy economics is a branch, is to investigate the efficient use of natural resources for the purpose of satisfying economic needs. The branch of energy economics, in particular, intends to provide an understanding of the operation of the relevant markets, to investigate the factors that influence the demand and supply of energy and the business structure of the energy industries.

Questions that energy economics is called to answer also come from policy designers or energy providers who want to forecast the demand for energy and who are concerned about the efficient use of natural resources for the production of commercial energy. Such questions arise in reference to:

- the implementation of pricing and tariff policies
- financing investments in energy production, distribution and conservation
- strategic analysis of energy businesses
- energy demand management
- restructuring and privatisation of public utilities
- regulation of markets

A problem that is very relevant to the issue of sustainable development is the pricing of energy. If energy is priced too cheaply, and its price does not reflect the marginal cost imposed on society and future generations by the depletion of an non-renewable energy source, then this market failure has to be corrected through some of the methods proposed so far. We need to keep in mind, though, that the optimal strategy for society does not always imply that a non-renewable energy source should not be exhausted. If using this energy source today is cheap, and, in the future, new technologies will allow a cheap replacement for this energy source, then it will be optimal to deplete this energy source today, instead of finding an expensive replacement. A problem that is more particular to the pricing of energy than to the pricing of environmental goods are deviations from competitive markets.

It is often the case that a source of energy is provided by a single seller, or at least a colluding group of sellers, while buyers are large in number and small in relative size. Typical examples are oil production and the O.P.E.C. countries. Even though regulators usually disfavour the formation of monopoly power by such sellers and try to reduce it through appropriate measures, it remains that such monopoly power, when used, gives rise to prices and reduces the quantities sold compared to a market with perfect competition. To the extent that this effect prevents the fast depletion of a non-renewable resource, the impact may not be that negative and a careful evaluation of the situation must precede any policy measures. Usually though, economists are very hesitant to correct one distortion, like the incomplete pricing of energy, with another distortion, like a market with a monopoly.

Industry restructuring – the Massachusetts example

An important issue of ongoing debate are pro-competition rulings by legislative bodies and the risk they pose to the profitability and viability of utility companies such as electricity suppliers. Such arguments have postponed energy market pro-competition rulings in many cases. On the other hand, in an agreement with the Massachusetts State Attorney General's Office and the Department of Energy Resources, New England based companies, Eastern Edison and Massachusetts Electric Company, have reached an agreement over an industry restructuring plan, where the following aspects of electrical service are identified.

1. *Electrical supply*. This can be the generation of electricity by a local, national and international company. Alternatively, it can be a company that purchases from the above companies large quantities of electricity and then markets them to consumers.
2. *Transmission*. Includes transmission of high voltage from power plants to local distribution lines within communities.
3. *Distribution*. Includes distribution of low voltage electricity to consumers, like homes and businesses.
4. *Customer services*. These services generally include metering, billing and outage reporting.

According to this plan, the consumers of electricity in about two thirds of the Massachusetts state area will be able to choose from which supplier they will purchase electricity. Consumers will, therefore, be able to choose from which source to purchase the electricity, regardless whether they purchase it directly from the generator, or from a wholesaler. According to their choice, the consumers will be billed by the generator for the cost of producing the consumed quantity of electricity.

As a result, the plan hopes to create competition among electricity generators, that will lead to more efficient electricity generation and lower prices for consumers. On the other hand, the consumers will not be able to choose a local distributor, as this service will still be provided by the present owners of the local networks. But the local distributors will bill the consumers only for the cost of distributing the electricity they have consumed.

As part of the plan, Boston Edison, a subsidiary of Eastern Edison, will sell off a large number of fossil fuel fired generation facilities. The multiple new owners of the sold facilities will acquire a significant position in the New England generation market and, at the same time, generation will be distributed among multiple producers, which will encourage competition. But Boston Edison will retain and continue to operate some of its facilities, including a nuclear power plant, and it will retain ownership and continue to operate its distribution network.

This bold plan to move from regulation to competition in the electricity market has also set high goals for environmental protection. It is expected that price competition will favour newer power generators that incorporate environmental protection measures and gradually force old generators, that produce at higher cost and tax the environment more heavily, to leave the business or replace their equipment. Furthermore, it has been estimated that the affected consumers will save at least US$ 3 billion over the first seven years of the transition to a competitive electric industry, thus lowering the cost of doing business and living in the affected area.

As new technologies become available for the production and use of energy that create lower emissions, they will see increased employment only if they are available at a cost that will permit them to be marketed competitively. The same is true for the use of new materials in the process of generating and distributing commercial energy. Environmental economists have to follow the technological advancements that take place and use the experience gained from experimental use of these technologies to conduct valid and comprehensive evaluations of projects and policy planning.

Wind energy

Wind energy is one of the great technological success stories of the past decade. The first wind power plants, installed in the early 1980s in California, were expensive, unreliable and costly to maintain. Since then, the technology of wind power plants has improved impressively. At good sites, the cost of a kWh produced has dropped below 4 cents. We cite the cost of installing a 600 kW wind turbine, as evaluated at a project in 1998, in the United States. The cost, including installation, was estimated to be US$ 585,000, and the annual operation and maintenance costs were estimated to be US$ 6,750. A very important decision, determining largely the profitability of such a project, is the location of the wind turbine at a site with high and stable wind speeds. High speeds are needed to generate large amounts of electricity, and stability is required to ensure constant use of the turbine and low maintenance costs.

The goal of encouraging the use of new, environmentally friendly, technologies to produce commercial energy is often at odds with the goal to provide cheap energy. So, while wind turbines can provide a kWh at a price below 4 cents in the United States, facilities using low-cost natural gas can produce the same amount of electricity at a cost that is around 3 cents, again in the United States. And the imminent deregulation of the electricity industry in that country may well drive the price of a kWh even lower, as the industry consolidates. So, while wind turbines will retain an advantage in areas that are far from other electricity production centres and have high wind speeds, like islands, their extensive employment may well be delayed by the deregulation of the electricity industry in the United States.

Pricing energy and reducing consumption

While the fair pricing of energy is one aspect of the problem, which is often favoured by measures that reduce the price of energy, the reduction of energy consumption is a different goal for governments. The aim is not only to reduce pollution, which follows from the production and consumption of energy, but also to help preserve non-renewable energy sources. Possible measures aiming towards these goals include:

1. *Direct quantity rationing.* Quotas simply forbid the consumption over a given amount of energy per consumer. Rationing was very common on oil during wartime in many countries.
2. *Public exhortation.* The government can call the public to voluntarily reduce consumption of energy in some extreme emergency. An example of successful public exhortation was the plead of the United States government during the Arab oil embargo for reduced electricity consumption.
3. *Fuel taxes.* Fuel taxes are in place in all countries, even though their height varies. Even though fuel consumption is inelastic in the short run, it is elastic in the long run. Therefore fuel taxes when set high can indeed encourage the use of more fuel-efficient equipment. The side of distributing income from fuel users to the government is not usually examined.
4. *Taxes on energy-consuming equipment.* Some studies argue that the fuel tax has the same results as taxes on energy-consuming equipment, but with less serious and distorting side-effects. A good example of such a tax is the *gas-guzzler tax* imposed in the United States on automobiles that exceed a certain consumption of gasoline per km.
5. *Regulations on equipment sold*. Such regulations are imposed in many countries. For example, certain European countries and the United States have regulations that require household appliances like refrigerators or electric furnaces to meet certain energy efficiency requirements. Also, the United States requires that the cars automobile makers sell meet on average certain efficiency criteria. That way, if an automobile maker sells a big, energy consuming car he also has to sell an efficient car, in order to keep the average fuel consumption of the cars he sells below the limit. Otherwise, if he wants to concentrate on high-profit large cars, he has to improve the efficiency of the cars he sells.

Why is environmental protection a problem in free-market economies?

The distinction between environmental economics and energy economics often becomes difficult to distinguish, as the aspects of energy economics that investigate the efficient use of resources and the reduction of the environmental degradations by energy production and consumption are also aspects of research for environmental economics. But aspects that investigate the global evolution of energy consumption and production, as well as the organisation of energy markets, require specialised knowledge of the technologies employed in the production and distribution of commercial forms of energy. Therefore, researchers in energy economics have to use their skills in engineering and the analysis tools provided by finance and economics to propose solutions to problems faced in the production and distribution of commercial energy, while, at the same time, evaluating the environmental impact of their proposals.

It is hoped that the reader of the present text, will understand why environmental protection is a problem in free-market economies. A problem that can be solved completely from a

theoretical perspective, and which one can attempt to deal with relative success in the real world. It also becomes clear that each case has to be treated individually. And while past experience can be used to treat each new case, one has always to take into account all characteristics of a new case and propose a policy that takes these into account. One should always keep in mind that all proposed policies have some merit. And a policy that failed in one case, may prove successful in another case. So no policy should be dismissed without previous evaluation. It helps a lot to use one's imagination to find low cost measures that are easy to implement and it also helps a lot to seek co-operation and information from persons that have had relevant experience.

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