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The Contribution of Economics to the Environmental Valuation Process

Chapter I Contents

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Introduction

For several of the players involved in impact studies, the environment must be taken into account not only through its natural dimension, but its economic and social dimensions as well. Thus, the update of the World Bank's environmental assessment guidelines (July 1997) cites the need to take into account the economic value of impacts on human health. This is not really new—the same requirements to take into account the monetary aspects of the environment and natural resources having been documented in impact studies for a number of years (not that this has led to any real change in practices…).

The interest in monetary valuation can be explained by a number of factors. First, failure to assess the value of the environment is often tantamount to attaching zero value to it and thus contributes to inadequate management. Monetary valuation can help inform the decision-making process at both the project assessment and policy levels (see Box 1). Environmental valuation also presents some interesting perspectives in terms of developing a set of indicators aimed at raising the awareness of decision makers and the population as a whole (see Box 2). Lastly, the whole issue of compensation valuation from a legal standpoint also constitutes an important factor in developing these valuation methodologies.

The present study is an introduction to monetary valuation of environmental impacts. The first section briefly describes the principles of monetary valuation, followed by the various sources of economic value and lastly the main methodologies used to assess these benefits. The second section examines the question of decision-making tools and the role of monetary valuation in decision making. Although our study explores the valuation of

benefits associated with the environment in a general way, special attention is paid to human health issues.

Monetary Valuation of Environmental Benefits

Basic principle of monetary valuation

According to economic theory, price is an initial indication of a good's usefulness, or, if you will, a measurement of the benefit it procures for the person consuming it. This approach is by no means new. As early as 1853, Dupuit argued that [TRANSLATION] "usefulness is what establishes value; the monetary sacrifice made by the transactor is what measures usefulness" (Garrabé, 1994). However, since many environmental goods do not have a market value, individuals cannot reveal their preferences for these goods through the price mechanism—hence the interest in seeking to determine the maximum sum that the consumer would have consented to pay for this item had such a market existed.

Viewed from this perspective, the economic valuation of environmental benefits is based on two central hypotheses of welfare economics which place the individual at the heart of the valuation procedure:

- individual preferences are the basis of benefits valuation;
- individuals are the best judges of their preferences (Desaigues and Point, 1993).

These preferences manifest themselves on a market (real or fictional) and are expressed in the form of an individual's willingness to pay (WTP), graphically represented by the demand curve. The benefit procured by the consumption of a quantity x of a particular good corresponds to the surface below the demand curve, namely the summation of expenditures made and the consumer's surplus (Figure 1). This surplus is the maximum

amount that individuals are prepared and able to pay, over and above what they have already paid, to continue to benefit from or use this good. In the case of an environmental good with no market value, the expenditure is zero,

therefore, but the economic value is not necessarily zero, since the economic benefit associated with this good corresponds to the consumer's surplus. This surplus, or WTP, can be measured by various techniques of monetary valuation (see section - Monetary valuation techniques). But before applying these techniques, one must first be able to identify the various sources of benefits associated with this good.

Figure 1: Total benefit

redo figure 1

Components of the economic value of the environment

The value of the environment can initially be associated with the benefits flowing from the direct and personal use of the environment. But the benefits associated with future (even optional) use, as well as the value attached to the environment in the absence of

direct use, either present or future, also help define the value of the environment. The notion of "total economic value" (Pearce et al., 1989) illustrates this broadened concept of value by comprising a wide range of motivation, including use value, either present or future, and non-use value (Figure 2).

Use value comprises all personal benefits flowing from the present use of a resource, whether this use is recreational, commercial or traditional. This could involve extractive activities, such as fishing, hunting or water consumption, and non-extractive activities, such as hiking or observation.

Indirect-use value refers to the benefits generated by the various ecological functions—hence its indirect and, above all, exclusive use nature. This value is based on ecosystems' capacity to generate and support life, assimilate and transform waste and produce the energy and materials used in the manufacturing process.

Option value is defined as the willingness to pay for an environmental good in order to preserve the possibility of continuing to enjoy it. What this entails, therefore, is preserving the environment with a view to its probable use in the future.

The notion of non-use value is divided into two categories. The first refers to heritage value, or the willingness to preserve the environment as a heritage to be handed down to

future generations. The second value source, existence, can be defined as the economic value that people attach to the fact that they know that the resource exists in nature. The heightened importance of this value is reflected by the legal recognition afforded it by the United States Court of Appeal in 1989, to the extent, however, that this concept is "seriously measured" (Arrow et al., 1993).

The relevance of this concept of "total economic value" in describing the benefits

flowing from the environment is the object of a fairly broad consensus in the literature. It should be pointed out, however, that the exact definition and scope of each of these value sources is subject to considerable discussion, particularly in terms of non-use value. What's more, it is often the case that these various value sources can only be assessed in an aggregated manner because of the complementary or substitutable relationships among the various benefits sources.

Figure 2: The various sources of economic value

to be inserted

Source: Adapted from Munasinghe, 1992

Monetary valuation techniques

To be able to apply the relationship between value and "willingness to pay" to environmental goods which are not transacted on an actual market, one must develop

procedures for revealing this willingness to pay. In the last 50 or so years, a number of techniques have been developed to assess this willingness to pay in a variety of circumstances.

The methods described in this section are grouped according to the classification adopted by the OECD (1995), to wit: the *methods for monetary valuation of physical effects*, the *revealed preference methods* and the *contingent valuation methods*. The first methods associate a price, directly measurable on a market, with the physical change in an environmental good or service. The second methods are used to deduce the market value with the help of prices which are indirectly associated with this good. Lastly, the contingent valuation method (CVM), is used to construct a fictional market where individual preferences can be expressed in the form of willingness to pay.

Some of these methods are commonly used for the monetary valuation of impacts on health; specifically, that is the case for human capital, contingent valuation and protection expenditure valuation methods (OECD, 1995). The expanded notion of environmental health can lead analysts, however, to focus on several types of benefits and can require the use of different valuation methods. Thus, our study describes valuation methods covering a relatively wide spectrum of benefits.

Monetary valuation of physical effects

The most direct method of evaluating environmental changes consists in associating the physical changes occurring during the period in question with the market price of these goods or services. Establishing the dose-effect relationship is central to this process, but this causal relationship is sometimes difficult to determine. According to the good being analysed, different methods can be used:

➢ Damage functions

Damage functions initially require a study of the physical relationships between a pollutant's *doses* and its *effects* on the productivity of natural environments. The economic value of this damage is then evaluated by assessing the market value of this production variance. The same type of approach can be used in considering the maintenance costs required to compensate for the damage to material goods.

This approach is commonly used because it refers directly to market price. The process can be used, for example, to measure in economic terms the effect of air pollution on crop yields or building dilapidation.

Ø Replacement cost method

At first glance, this method appears relatively simple. The idea is to determine the physical damage, and then to assess the costs required to restore the degraded environment. The approach gets complicated, however, when the time comes to determine the desired level of restoration (must the environment be restored to its initial state or to an "acceptable" state?). Also, the restoration must be feasible. The approach is impractical, therefore, in the case of irreversible loss.

➢ Human capital method

The traditional approach to the valuation of human life is that of "human capital". To begin with, a dose-effect-type relationship must be established between

environmental changes and the resultant variance of the mortality or morbidity risks. The valuation of the losses in human life, or in days of incapacity, is then

transposed in economic terms by using, as a value of these losses, the discounted flows of lost income as well as the processing costs. The value of human life is thus reduced to its only productive aspect, which raises a serious question of ethics: the life of someone with a lower income expectancy possesses less value.

Revealed preference method

In cases where environmental goods do not possess any market value, various methods can be used to assess individuals' preferences on the basis of behaviours observed on markets that are complementary or alternative to the environmental market. These methods assess economic value by referring to an actual expenditure, thus limiting the sources of bias in the valuation. These methods can be used to assess use values only, however.

- Transportation cost method

The transportation cost method seeks to measure the value of the consumer's surplus associated with a particular site, on the basis of the expenditures incurred to travel from home to the site. Studies using this technique, which has been recommended since 1979 by the Water Resources Council for project assessments, now number in the hundreds in the United States.

The initial approach used in the 1960s was relatively simple. By estimating the

average transportation cost for individuals hailing from the same region and by increasing this transportation cost with the help of a mock toll, one can determine the effect of this new cost on the visitation rate. By increasing this mock price so high that the number of visitors is nil, one obtains the total number of visitors for each possible price level. Once this demand function has been obtained, one can infer the consumer's surplus.

The transportation cost variable cannot in and of itself explain, however, the visitation rate for a given site. The analytical technique has been considerably refined since the first analyses, therefore; now it is possible to take into account other variables explaining the visitation rate, such as user preferences, user income, the features of the site, the presence of alternate sites, etc. The equation describing the visitation rate can therefore take a far more detailed form, which will then serve as a basis for evaluating the surplus.

Although this method is widely used, it poses a number of practical difficulties associated with, among other things, determining the transportation cost. Thus, the time opportunity cost, consideration of the costs associated with the purchase of durables used for the activity, accommodation and living expenses associated with the travel, the portion attributed to the site being studied in multi-site trips, delineation of the alternate sites and, lastly, characterization of the environmental benefits all entail discretionary choices.

- Hedonic approach

This approach seeks to identify the relationship between the value of a market good and certain environmental quality indicators, and then to infer from this relationship a monetary value with environmental characteristics. This methodology is particularly well adapted to studying the real estate market, where one can easily see how the value of two identical residences will differ if

they are located in a physical environment possessing significantly different characteristics. However, since the price of this real estate can be explained by a host of variables, the choice of these variables will be determinant; too few independent variables will not allow an accurate valuation of the contribution by environmental factors, and too many can lead to correlation biases.

In practice, this approach requires reams of data and a relatively awkward statistical analysis. Furthermore, the real estate market must function the way it is supposed to and the environmental characteristics must be clearly perceived and evaluated by the owners. These constraints limit the use of this method to large-scale studies on the impact of air pollution (a classic example: the noise produced by airplanes).

- Protection expenditures

When there is a change in the quality of the environment, individuals can try to protect themselves against this deterioration through various expenditures, such as installing water filters or purification devices and taking measures to combat erosion. Assessing these expenditures provides an initial valuation of individuals' preferences.

This method is relatively simple and has the advantage of being based on observed behaviour. Environmental expenditures must not be confused with environmental costs, however; otherwise, a portion of the information is perceived as the entire impact on the environment. Moreover, the alternatives remain imperfect and the hypothesis that people know the scope of the risks to which they are exposed is not necessarily verified.

Contingent method

Developed in the 1950s, the contingent valuation method has been significantly upgraded over the past few years, and the number of valuations has risen sharply, particularly in the United States. This is attributable to the fact that this method can be applied to any circumstance and, above all, that it is the only valuation technique that allows us to measure economic value in its entirety, including non-use value.

The principle underlying this technique is relatively straightforward. In a normal market, paying a certain amount of money for a particular good reveals the economic value that individuals attach to this good, within the confines of their budget. The contingent valuation method seeks to imitate this scenario through a survey, whereby individuals reveal their willingness to pay for these environmental goods in a hypothetical market.

Basically, the survey can be divided into three sections: a physical description of the good to be assessed and any potential modifications being contemplated; one or more questions aimed at determining maximum willingness to pay to obtain the improvement or avoid the deterioration in question[1]; and a series of questions in order to describe the respondent's

[1] In cases where individuals are confronted with a loss of an environmental good for which they feel they hold the rights, they will claim compensation, and one will talk in terms of "willingness to receive". In practice, however, the consensus

socio-economic characteristics with a view to constructing an explanatory model for WTP.

While the process seems relatively simple, the hypothetical nature associated with the absence of actual payment and the many biases that can result have given rise to a large body of literature. These biases involve, among other things, the respondents being led to deliberately distort their responses, the presence of implicit values in the questionnaire, scenarios which incorrectly describe the good being assessed and problems having to do with benefit aggregation and sampling (Mitchell and Carson, 1989).

It should be pointed out, however, that the validity of this method, particularly in terms of the appraisal of non-use value, was the focus of discussions by the US National Oceanic and Atmospheric Administration panel of experts. The panel concluded that [TRANSLATION] "under certain conditions[2], contingent valuation studies provide useful information… [which is] sufficiently reliable to serve as the starting point for a legal process of assessing damages, including for loss of existence values" (Arrow et al., 1993).

Value transfer

Having the methodological tools necessary to measure the various sources of benefits does not mean that these valuations can be conducted for decision making. The information cost can be relatively high, and the time needed to design and execute the process can be excessive. These constraints have led to *value transfers*, the use of values obtained in an analogous context but in another place and time.

surrounding the appropriateness of measuring willingness to pay is almost unanimous.

[2] It is recommended that the respondents be well informed of the damage to be assessed and of the available substitutes; the means of payment must be clearly presented, with an emphasis on budgetary constraints; the referendum approach should be used, and a WTP-type approach should be used instead of a WTR-type approach.

The US Administration recommends taking into account three criteria to ensure that the value transfer is credible:

- the users and natural resources (or environmental services) examined during the initial study must be comparable to those of the situation being studied;
- the changes in quality or in the quality of the natural resources (or environmental services) examined during the initial study must be comparable to those of the situation being studied;
- the initial study must be a quality exercise (NOAA, 1996).

Desaigues and Point (1993) add that the property rights must be identical, and that it is always preferable to transfer the demand function and then determine willingness to pay rather than directly transferring the value of the willingness to pay.

With a view to facilitating these value transfers, Environment Canada has developed an automated database containing several hundred studies. Box 3 describes in greater detail this *Environmental Valuation Reference Inventory.*

The specific case of mortality and morbidity assessment

As mentioned previously, the traditional approach to economic valuation of human life is that of human capital. Beginning in the 1970s, another approach has found its way into the literature, that of "willingness to pay". However, since one cannot measure willingness to pay in order to preserve life (an infinite value, obviously), willingness to pay is measured instead to modify probability of death. This takes the form of the maximum amount individuals are prepared and able to pay so that an undertaking resulting in a reduction of mortality or morbidity risks can take shape. The reverse is also true, since one can measure the minimum

amount that individuals demand to receive to accept an increase in risk.

How then does one determine this willingness to pay (or receive)? Two approaches appear in the literature: the hedonic approach and the contingent approach.

The former is based on direct observations of behaviour when money changes hands, implicitly or explicitly, in consideration of a change in risk level. Thus, studying the impact of risks on salaries allows one to determine the premiums paid in higher-risk sectors. This approach is not without its difficulties, however. First, the labour market does not necessarily function perfectly, which can produce situations in which individuals are unable to obtain fair compensation despite the change in risk level. Second, there can be a *selection bias*—persons accepting jobs posing the highest risk are likely unrepresentative of the population. Lastly, the valuation is based on the change in risk perceived by the individual, which is not necessarily consistent with the actual change (Lanoie, 1993).

The contingent approach is used to create a mock market and directly assess willingness to pay (or receive) when there is a change in risk level. This approach presents a number of advantages: direct possession of the information being sought; the sampling procedure ensures the representativeness of the group selected; and certain segments of the population—those most affected by the undertaking—can be targeted. On the other hand, this method raises the whole question of the potential construction of the value by the questionnaire and the many biases that can be present in this type of valuation. Moreover, certain authors doubt the appropriateness of having the general public assess questions involving probability variations.

Lanoie (1993) has identified 37 studies on human life, 22 of which use the hedonic approach. Of the 37, he has chosen 21 which he considers to be more reliable; armed with these, he

estimates the value of a statistical life to be in the order of C$5.6 million (1991 dollars). The author concludes, however, that in practice, analysts and decision makers refer more to the human capital approach, and thus to the "cost of losses of human lives" rather than the value of human life.

Undeniably, however, the question of attaching monetary value to human life makes some people feel uncomfortable. The question is even more delicate when the valuation focuses on an international issue and involves developing countries. The report by the Intergovernmental Panel on Climate Change notes that [TRANSLATION] "there are few studies for the developing world, and it is difficult to say what the results would be using these techniques. To the extent that willingness to pay is conditioned by individuals' capacity to pay, the results might be far lower. A preliminary study for India estimates "personal valuations" at around $120,000" (IPCC, 1996).

Box 1: Monetary valuation of the benefits flowing from the Clean Air Act

The EPA recently published a comprehensive monetary valuation of the benefits stemming from the implementation of the Clean Air Act (CAA) for the period 1970-1990 (EPA, 1997). This study is an interesting example of an assessment of the benefits of an environmental policy in which the valuation of the components associated with human health occupies an important place.

The approach used seeks to evaluate the benefits and costs of two alternate scenarios: the first describing the actual implementation of the CAA from 1970 to 1990, the second reflecting a hypothetical situation where no air pollution control program is put in place during this period.

First, the direct costs associated with the CAA from 1970 to 1990 were assessed at $523 billion (1990 US dollars). These expenditures allowed a significant reduction in polluting emissions in relation to the "non-control" scenario, to wit: around 30% fewer emissions of nitrous oxide, 40% for sulfur dioxide, 45% for volatile organic

compounds, 50% for carbon monoxide, 75% for particles and 99% for lead. It should be pointed out, however, that depending on the pollutant, this emissions reduction does not necessarily lead to a corresponding level of improvement in air quality.

Next, the air quality improvement resulting from this reduction in emissions was associated with a series of benefits from the standpoint of human health, welfare and ecological systems. Where the state of knowledge permitted, the importance of the benefits was quantified using various functions appearing in the literature. In particular, that was the case of the effects of several pollutants on human mortality and morbidity, the effects of exposure to lead in children's cognitive development and the effects of air pollutants on agricultural productivity. Benefits for which a quantified estimate of the dose-effect relationship is not available are not included in this cost/benefit analysis. Thus, the main sources of the benefits flowing from the CAA can be associated with a lower incidence of mortality caused by suspended particulates and lead, lower incidence of chronic bronchitis caused by particulates, a positive impact on the cognitive development of children exposed to lead, a lower incidence of respiratory problems caused by particulates, ozone, nitrous oxide and sulfur dioxide, a lower incidence of hypertension caused by lead and fewer hospital admissions caused by particulates.

Since the value of each of these avoided risks does not exist on a market, it was inferred with the help of various monetary valuation techniques. Thus, contingent analysis was used to assess chronic bronchitis and respiratory problems; the protection expenditure approach was used to measure hypertension and hospital admissions; as for the impact of lead on children, the valuation was obtained by considering the decline in expected income and the increase in social spending, for lack of a better estimate; the mortality risk valuation was based on the results of 26 studies, of which 5 used contingent analysis and 21 used hedonic analysis of the labour market. On the whole, the benefits associated with the CAA during the period 1970 to 1990 were assessed at between $5.6 and $49.4 billion, with a central value estimated at $22.2 billion (in 1990 US dollars). Compared to the cost of the CAA, the net benefit ranges between $5.1 and $48.9 billion with a central value of $21.7 billion. Clearly, therefore, the CAA makes economic sense, especially since the valuation is underestimated due to the exclusion of several non-monetary benefits. The study also identifies several areas where uncertainty, be it physical or monetary, remains very high and should be the subject of research. But this study also illustrates the difficulties of assessing environmental policy, from both a physical and a monetary standpoint. Thus, certain agencies of the US administration have expressed reservations about several of the report's central hypotheses, specifically: the assessment of the deterioration in air quality

between 1970 and 1990 in the absence of the CAA, the methods used to assess the incidence of illness and premature mortality avoided thanks to the CAA, and the methods used to estimate the value that people attach to these avoided risks. We are faced here with the classic criticisms levelled at this approach, namely the assessment of the "dose-effect" relationship and the appropriateness of the monetary valuation techniques used to assess these effects.

Box 2: Monetary valuation of environmental functions

The goods and services produced by ecological systems and stocks of natural capital are essential in maintaining life on earth. They contribute to human welfare, both directly and indirectly, and thus constitute a portion of the planet's total economic value. However, the value of environmental services is not fully taken into account by markets or adequately quantified on a par with economic services; often, therefore, not enough weight is attached to it during decision making. Consequently, it may be useful to determine how a change in the quantity or quality of this natural capital can modify this well-being.

A collective of 13 authors published in *Nature* an overall monetary valuation of 17 services produced by the ecosystems of 16 biomes (Costanza, 1997). The analysis, however, excludes non-renewable resources (fossil energy and minerals) and considers neither the ecosystems' inherent value nor the value that can be attached to the minimal stock needed to maintain ecological balance. Rather, the study assesses how small changes on a large scale or radical changes on a small scale can affect well-being. Using values published in the literature for the various ecological services, the authors estimate the value of all these environmental goods and services at between US$16 and $54 billion a year, with a mean value of US$33 billion. This "minimal" value can be compared to world marketed production of nearly US$18 billion. These results indicate that if there was a desire to replace these environmental services at their marginal value, gross world product would have to be increased by 180% solely to maintain an equivalent level of well-being. Even if this were possible, it would not lead to an improvement in well-being because it would merely replace existing services—ignoring the fact that several of these services are literally irreplaceable.

The authors recognize that there are many empirical and conceptual problems with this type of valuation.

What's more, the argument can also be made that preserving ecosystems is a moral issue. But as far as the authors are concerned, moral questions and economic arguments are not mutually exclusive, and such discussions can and must be carried out in parallel. In this context, the exercise remains useful in attaching a relative value to ecosystems, establishing a preliminary approximation of the scope of these services, identifying elements about which there is little information, and stimulating research and debate. While not contributing directly to decision making, the development of such "macro-indicators" helps raise awareness.

Box 3: Environmental Valuation Reference Inventory (EVRI)

The database set up by Environment Canada, with the support of the EPA, identifies several hundred studies on monetary valuation of environmental goods and services. The merits of this analytical instrument also derive from the fact that it has been constructed in such a way as to allow the selection of the most relevant studies, as judged against a series of criteria such as the various environmental goods and services, geographic characteristics or valuation techniques.

Obviously, the database alone does not allow the entire value transfer procedure to be carried out; what it does, however, is enable analysts to identify more rapidly and at a lower cost the most relevant studies with a view to subsequently carrying out this transfer. In the human health sector, for example, the database provided analysts with access to over a hundred studies in the summer of 1998.

Monetary valuation and decision making

Cost-benefit analysis

All projects, be they private or public, generate costs and benefits. For the individuals or business carrying out a project, a *financial analysis* should enable them to determine the private viability of the project by comparing all the costs and benefits assumed by the proponent. While such an approach can be used to justify a project from a business standpoint, it cannot be used to justify it from a societal perspective.

In environmental terms, the difference between the private viability and social viability of a project can be explained by the presence of externalities—losses of benefits resulting from the production or consumption of a good in the absence of financial compensation. Thus, although a project's proponents must put in place mitigation measures to limit the project's negative impacts, the residual damage to ecosystems or human health is not considered as a cost if responsibility for this damage is not assumed by the proponents (such would be the case, for instance, of the impact of airborne pollutants on human health). The cost-benefit analysis seeks to rectify this shortcoming by comparing the costs and benefits of a project for society as a whole. This shifts the frame of reference from private viability to social viability.

The principle is relatively simple: if the sum of the benefits stemming from a project exceeds the costs (therefore, if the benefits/cost ratio is > 1), the project can be considered as economically justified for society.

The relatively "simple" nature of this decision-making rule explains why this process has become so widespread. The process is not without its complications, however (and on several levels, at that). First, all the monetary costs and damages must be taken into

account; this involves having proper valuation procedures in place and addressing the distribution of costs and benefits. Second, since the damages and costs associated with a project are spread over time, they must be *discounted* to take into account time preferences. Third, risks and uncertainty can vary from one project to the next and must be taken into consideration.

- monetary valuation

A large part of the research on cost-benefit analysis has often consisted of an extension of the type of benefits that are quantifiable and measurable in monetary terms. This can be explained by the fact that the analysis is based on an exhaustive compilation of the costs and benefits and that, without a valuation of some of these costs or benefits, doubt could be cast on the conclusions of the analysis. In practice, however, it is rare that all the benefits and costs are taken into account. As we saw in the previous section, several methodologies can be used to assess benefits in their entirety. This valuation of environmental damage (or of benefits, in the event of favourable impacts) is not systematic, however, since scientific knowledge cannot always be used to assess these impacts even in physical terms (see Box 1) and the valuation of individual preferences does not necessarily take into account all the benefits (see section on Cost-effectiveness analysis).

- equitableness

The principle underlying this decision-making rule implies that the benefits are sufficient to offset the costs. However, the CBA does not mean that this compensation between those who reap the benefits and those who must shoulder the costs will be carried out; it simply means that it could be carried out. What's

more, since the analysis does not systematically take into account the distribution of these costs and benefits, one needs to pay special attention to the equitableness of this distribution.

- taking time into account

The need to take time into account stems from the fact that individuals do not attach

the same value to costs and benefits that are spread over time. This *time preference* simply reflects the fact that an individual prefers receiving $1000 today to receiving $1000 20 years from now. Moreover, there is an *opportunity cost* of capital, since the same sum can be invested in various projects or simply loaned out at interest.

To compare sums at different points in time, they must be discounted.

$$\text{Discounted value of A} = \frac{A}{(1 + \text{discount rate})^{n}}$$

with n = number of years

This discount rate has given rise to a large body of literature and a great deal of controversy, since it can significantly influence the results of the valuation; thus, the higher the discount rate, the lower the present value of future costs and benefits[3]. If it is conceivable that individuals possess, on an individual basis, a marked preference for time, this preference is surely lower in the case of societies, since they can be considered as quasi-immortal (World Bank, 1991). The discount rate used for CBAs is therefore lower than the opportunity cost of capital and reflects this social time preference.

The decision-making criterion for judging a project's acceptability is therefore the discounted benefits / discounted costs ratio or the difference between the sum of the discounted benefits and the sum of the discounted costs (or the *net present value)*. However, the influence of the discount rate on these values warrants a sensitivity analysis with several rates, with a view to demonstrating the influence of this rate in the

[3] For example, a sum of $1000 in 20 years has a present value of $148.64 with a rate of 10% and a present value of $672.97 with a rate of 2%.

end result.

- risk and uncertainty

  Lastly, several environmental impacts are characterized by the uncertainty surrounding them over the long term. However, as we gain more knowledge, we can express our uncertainty in terms of the probability of seeing them occur. This shifts the focus from an uncertainty analysis to a risk analysis. It can therefore be worthwhile to invest in information so as to be able to diminish uncertainty. Decision makers' aversion to risk and uncertainty should also be factored in when analysing the results.

Cost-effectiveness analysis

If the optimization-type approach that characterizes the CBA constitutes a powerful tool to support the decision-making process, it does not necessarily conform to a sustainability logic. Indeed, the methods for assessing the depreciation of non-market natural capital can lead to [TRANSLATION] "confusion between economic optimum and sustainable use of this capital. There is nothing to indicate that the economic optimum corresponds necessarily to the thresholds for use of the latter" (Faucheux and Noël, 1995).

What we are dealing with here is not a simple question of precision in assessing economic value or of the ability to measure the total value of the environment. Apart from this precision, the very principle of optimization implies that one can substitute natural capital and manufactured capital, and that a decline in the benefits generated by the environment can necessarily be offset by economic gains. This is tantamount to denying the existence of any environmental distinctiveness and implying that ecological functions are all substitutable.

Given the uncertainty as to the degree of substitutability and the irreversibility characterizing

several environmental issues, *the precaution principle* should lead us to envisage only with the greatest caution any serious or irreversible change in the environment (Godard, 1997). The maintenance of environmental functions can thus be considered as a constraint, and this constraint cannot be defined solely on the basis of economic criteria.

This normative approach, used to determine *a priori* a level of environmental protection, is outlined in Figure 3. The events shown on the right respond to criteria for maximizing individual benefits, since the damage is reversible and minor. The decisions shown at the centre are often taken collectively by the various agencies, and the cost-benefit analysis can also be used as a decision-making support tool. The events shown in the upper left corner are major and irreversible; the decisions relating to these changes are taken according to a process of collective choices, often determined or constrained by legislative decisions. In the latter case, it is necessary to organize information differently and focus on the minimum standard to be preserved and on the most efficient means of implementation.

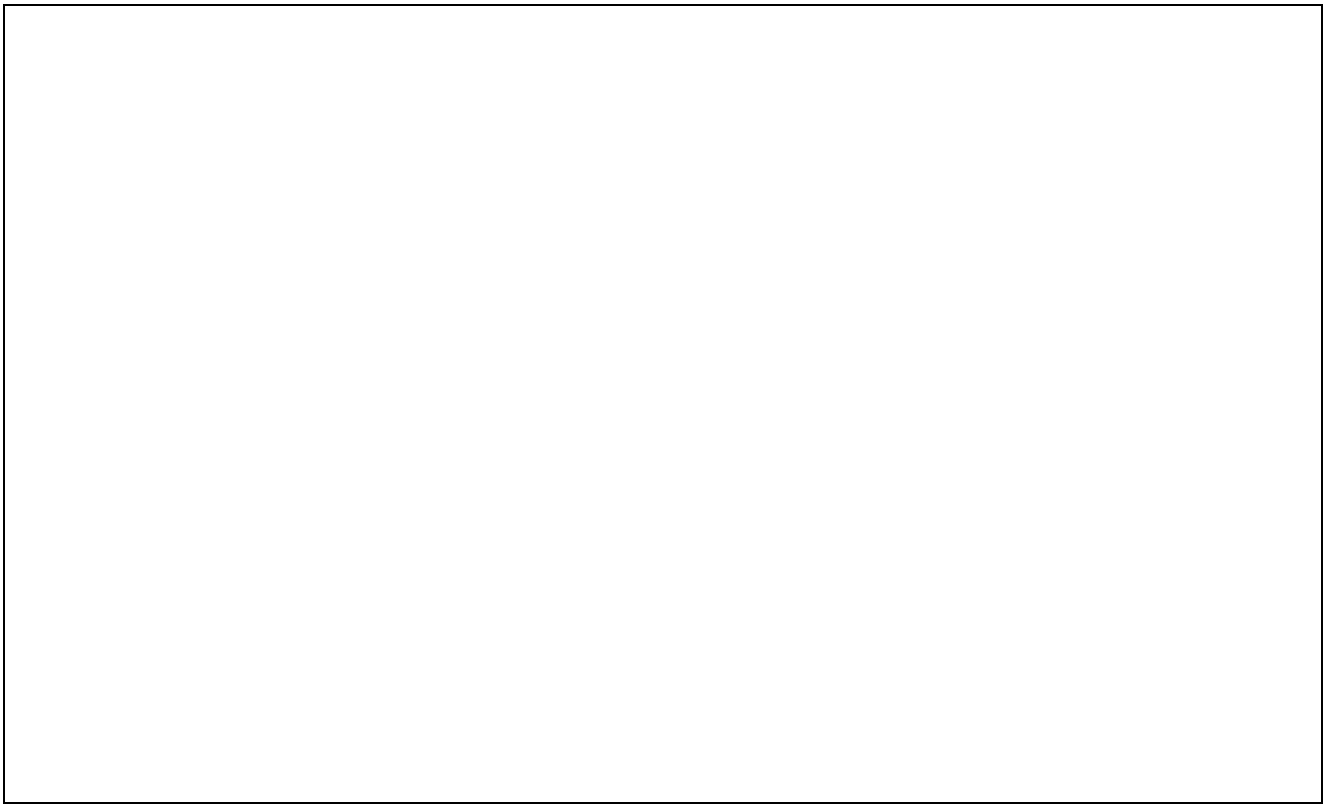
In this context, although economic valuation of benefits can lead to improved environmental decisions, the economy cannot take the place of collective political decisions for questions of distribution, including resource rights for future generations or within the current generation. For certain types of decisions, the issues of sustainability and ecosystem value ultimately require collective choices via a political process. Decision makers do not need a sophisticated cost-benefit analysis to justify actions that prevent significant and irreversible environmental effects. In these circumstances, an analysis of the efficiency of the various policies or actions to prevent such consequences is sufficient (Bingham et al, 1995).

Victor also points out that questions relating to sustainability of natural heritage [TRANSLATION] "are not questions that can be answered solely from an economic perspective. The answers to these questions are largely social, political and ecological and

involve global as well as local considerations" (Victor, 1994). In this context, a case can be made that the question of monetary valuation no longer centres on a measurement of willingness to pay but rather on the sum of the costs of preserving or attaining a defined objective in a multidisciplinary manner. Economics plays a key role in determining the most efficient approach for achieving this objective.

Determining these minimal standards cannot be dissociated, however, from the question of the development outlook which they provide, the compensation which they can necessitate and the financing of these measures. In this context, the contribution of economics to the valuation of environmental impacts is not confined to simply monetary valuation, but also includes an analysis of the policies put in place from the standpoint of efficiency and equity.

Figure 3: Scope of monetary valuation methods



Source: Adapted from Bingham, 1995

Multi-criteria analysis

To the extent that these answers to the environmental questions are of an ecological, social, political and economic nature (i.e. decidedly multidisciplinary), compromises are necessary between requirements that are sometimes contradictory. Multi-criteria analysis offers a series of methods or procedures which tend to formalize these compromises to a certain extent.

After defining the problem to be dealt with and choosing a series of valuation criteria, either qualitative or quantitative, an aggregation procedure is used to integrate and weigh all these criteria. The appeal of this approach lies, of course, in its ability to take into account quantitative variables, including economic valuation of benefits, and qualitative variables. The procedure leading to decision making is thus not confined to purely economic criteria.

Conclusion

Regardless of one's own views concerning the role the market should play as allocator of resources in society, the corollary of this being the role the State should play, one must not lose sight of the fact that the market is a social construct. It is a tool in the service of society for attaining objectives set by society. Accordingly, it is not for the market to develop conservation priorities, especially when these priorities involve inter- and intra-generational equity (Réveret and Webster, 1997).

As part of an environmental impact study, one should determine, as best one can, the value of the gains and losses associated with the various components of the environment. That said, this variable should not become the only decision-making criterion. In this context, the cost-benefit analysis can be used to inform but not dictate decisions relating to environmental policy, programs and research (EPA, 1997).

While the methodology and reliability of monetary valuation procedures have made significant strides, it seems that the tendency to take into account monetary valuation in the decision-making process, specifically as part of impact studies, is not totally clear as of yet. This is opening up some excellent avenues for research.

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