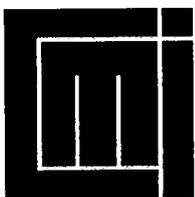# Cost-Benefit Analysis, Discounting, and the Environmental Critique: Overloading of the Discount Rate?

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**Report**

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## Summary:

The use of (high) discount rates in cost-benefit analysis is being criticized in the environmental debate. In particular, some feel that high future environmental costs do not get a fair hearing in a project appraisal due to the use of high discount rates. This paper explores first the relationship between the discount rate and environmental degradation. The link is ambiguous, though the overall effect of a lower discount rate may be more environmental friendly policies. Secondly, we discuss factors which should determine the discount rate according to economic theory, and to what extent environmental considerations can be brought into this framework. Finally, the paper briefly reviews other ways of bringing environmental considerations in the analysis, e.g. taking risk, uncertainty and irreversibility into account and including sustainability constraints. The conclusion is that the present tendency of overloading the discount rate should be avoided.

## Sammendrag:

Bruken av (høy) diskonteringsrate i nytte-kostnadsanalyser er blitt kritisert i miljødebatten. Det hevdes bl.a. at store miljøkostnader i fremtiden ikke blir tilstrekkelig tatt hensyn til i prosjektvurderinger dersom diskonteringsraten er for høy. I denne rapporten undersøkes først sammenhengen mellom diskonteringsraten og miljøforringelser. Selv om denne sammenhengen ikke er entydig, vil en lavere rate i de fleste tilfeller føre til mer miljøvennlige beslutninger. Deretter diskuteres faktorene som ifølge økonomisk teori bestemmer diskonteringsraten, og hvorvidt miljøhensyn kan trekkes inn i dette oppsettet. Til slutt vurderes andre måter å bringe inn miljøhensyn i prosjektanalyser, som f.eks. ved å trekke inn risiko, usikkerhet og irreversibilitet, og ta hensyn til begrenset bærekraft. Konklusjonen er at en bør søke å unngå den nåværende tendens til å overbelaste diskonteringsraten.

## Indexing terms:

Cost-benefit analysis
Discount rate
Environment
Economic theory

## Stikkord:

Nytte-kostnadsanalyse
Diskonteringsrate
Miljøhensyn
Økonomisk teori

# Contents

*Figures and tables*

# 1 Introduction[1]

> It is time for a serious reappraisal of the Government's policy on discounting costs and benefits in the evaluation of public policies, programmes, and projects (Lind, 1990).

The discount rate used in a cost-benefit analysis (CBA) is critical for the social profitability of projects or policies with large environmental impacts. Many people feel that potentially large or even catastrophic environmental consequences in the future, do not get a "fair" hearing when we discount these costs to present values. We ignore our grandchildren, or at least we ignore them by 10 per cent per annum.

The aim of this paper is to survey some of the relevant literature and theories for a discussion of the environmental critique, and how environmental considerations could be included in an economic assessment. The emphasis is on general models and concepts; we do not for instance go into the discussion on how the "correct" rate should be estimated in practice. To some extent, we shall relate the discussion to the particular situation in developing countries.

Chapter 2 elaborates the environmental critique raised against discounting in CBA. This critique is based on the assumption that a lower rate would promote environmental conservation. Chapter 3 discusses this relationship, and shows that the effect of a lower discount rate is ambiguous. As the environmental effects frequently are related to long term costs and benefits, a lower discount rate would give these higher present values. However, a lower rate could also make investment projects with negative environmental impacts more acceptable.

We discuss three possible ways of including environmental considerations into an economic assessment. The first one is to lower the discount rate in order to give higher weight to future environmental costs and benefits. As the effect of a lower discount rate is ambiguous, even though the overall effect on environmental quality may be positive, this alternative would not be a very precise means. But in order to conclude as to whether the rate should be adjusted, one needs to discuss the rationale behind discounting in economic theory. This is done in chapter 4, which explores whether within the theory there may be any arguments for lowering of the discount

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rate in the presence of large environmental effects. The conclusion is that the fact that a project may have negative environmental impacts is *not* an argument, *per se*, for using a lower discount rate. Indirectly, however, the sum of negative impacts on the environment may lower future economic growth, which implies lower social discount rates. Secondly, the rationale for pure time preference is questioned, particularly when it comes to decisions significantly affecting the well-being of future generations.

A second way to include environmental considerations in the CBA would be to extend the traditional method, which in the formal analysis has given very limited attention to environmental impacts . Ways of extending the traditional approach are reviewed in chapter 5, where emphasis is put on risk and uncertainty, and how this should be handled. Uncertainty associated with environmental costs and benefits may also give an argument for adjusting the discount rate. A third possibility would be to introduce additional or alternative criteria into the analysis. Chapter 6 discusses two possibilities in this respect, viz. sustainability constraints and the Safe Minimum Standard approach. The main conclusions are summarized in the final chapter.

## 2 The environmental critique of discounting

The importance of the discount rate for the assessment of future costs and benefits is illustrated by a simple example. Consider a toxic waste that may have catastrophic consequences in a 100 years time. Suppose the probability of this catastrophe occurring is 10 per cent, and that the cost would then be, in today's prices, $ 1 billion. The expected cost then becomes $ 100 mill. Using a discount rate of 5 per cent per annum, the present value of the expected costs will be $ 760 449. But if we double the discount rate to 10 per cent, the present value becomes only $ 7 257. This shows how significant future costs may be reduced to next to nothing through the discounting process. Secondly, it also illustrates the sensitivity on the present value by changing the discount rate. When the costs appear 100 years from now, reducing the discount rate from 10 to 5 per cent increases the present value more than 100 times. This has led some to label this feature the "tyranny of discounting".[2]

A number of environmental groups and environmentally concerned individuals argue that the discount rate should be lowered in order to give

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[2] For example, Pearce et al (1989) use this term. They do not, however, agree with the environmental critique of discounting.

future, negative environmental effects proper weights in the decision making process. Sandra Postel of the WorldWatch Institute writes, in "an article on a new 'eco'-nomics", that "among the first priorities is to make public investments place more weight on the future rather than systematically undervaluing it. One solution is to lower the discount rate to a level closer to the real rate of capital productivity, around 1 to 3 per cent" (Postel, 1990, p. 26). Others have also suggested to use a lower rate. In the United Kingdom, for example, the Treasury uses a special low rate of 3 per cent for afforestation projects, whereas the normal rate is 5 per cent.[3]

Others have gone further and argue that for certain resources or environmental effects one should apply a *negative* discount rate rather than the normal positive one (Goodin, 1982 and Hall, 1990). The arguments have been of different kinds. One is to lower the rate in order to adjust for risk and uncertainty related to environmental effects; another is to lower it to reflect the fact that environmental goods will be increasingly appreciated and valued by the population, partly because these goods will become increasingly scarce, and partly because environmental goods seem to be increasingly demanded by higher income levels.[4] These arguments are definitely valid and should be taken into account in the analysis, but it is not obvious that lowering the discount rate is the appropriate way of doing this.

There is, however, a third argument, which raises much deeper issues concerning the basic assumptions in welfare theory. This critique against a uniform discount rate in the analysis is based on a rejection of the assumption that (all) environmental goods can be substituted for other goods, and that they therefore should be treated separately by a different discount rate. Goodin asks whether the assumption of smooth substitution between all goods in the welfare function holds. "Were everything reducible to monetary equivalents, everything would have to be discounted the same way. ... If, on the other hand, not everything is cashable in terms of everything else, then the case for uniform geometrical discounting of all goods fails to follow" (p. 60). The essence of the argument is that there is

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[3] See Pearce et al (1989) chapter 6 for a discussion.

[4] This is to say that the income elasticity for environmental goods is higher than 1. Cooper (1980) notes that "this supposition seems plausible enough, at least in those cases where environmental damage is not an immediate threat to basic matters like food and shelter" (p. 71). When the latter is the case, as in many developing countries, there is little meaning in talking about high income elasticities.

an important class of "non-tradable" goods[5] which can be discounted only in their own terms.[6] Goodin refers to human life as perhaps the best example of a non-tradable good. But, he also notes that most goods are not tradable over their entire range. There exists some minimum quantity and quality of certain goods that we would insist on before we are willing to enter an exchange for any other goods, "breathing opportunities" being an example.

This critique questions the "choice-value thesis" of neo-classical economics (Broome, 1978). The neo-classical assumption that all goods in principle are commensurable, can be traced back to Aristotle's statement that "all things that are exchanged must be somehow comparable". By judging from the choices and trade-offs we make, one can implicitly assign values to the different goods.[7] This critique raises new issues, and we shall not go further into this discussion.

In summary, we may distinguish between two separate views: The first is that the discount rate should be lowered generally in order to put more emphasis on future environmental effects. The second suggests a lower rate be used for certain environmental costs and benefits (resources). In what follows, we shall mainly concentrate on the first. The latter raises deeper issues regarding the philosophical foundations of welfare theory and CBA. As the framework for discussion below is within this (neo-classical) paradigm, it cannot be used to judge the validity of the second view.

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[5] The meaning of this term should not be confused with the way it is used in the theory of international trade.

[6] This argument is similar to one presented by Georgescu-Roegen (1954). He writes that "it has long since been observed that human needs and wants are hierarchized. ... this hierarchy is the essence of any argument explaining the principle of decreasing marginal utility" (p. 513). This hierarchy of wants makes him conclude that all human wants cannot be reduced to a common basis. He introduces the *"Principle of the Irreducibility of Wants"*, and regrets that this have escaped the attention of neoclassical economists. This observation is still valid, almost four decades later.

[7] Broome (1978) underlines that "when two alternatives are incommensurable, they are not made commensurable by the mere fact that people can choose between them" (p. 62). Goodin (1982) similarly concludes that "we may make a choice between nontradable goods if we were *forced* to choose. But the fact that we do choose does not, under these circumstances, prove that we have been fully compensated for the loss in one good by the gain in another. This being the case, any trade-off information or common metric of value derived from such forced choices should *not* be used in trading one of the goods for another *whenever* the opportunity arises. It may properly be used only when the trade is *inevitable*, and we are forced to make a hard choice" (p. 62).

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# 3 The influence of the discount rate on environmental degradation

## 3.1 A purification project

The fundamental role played by the discount rate in cost-benefit analysis (CBA) is to put costs and benefits in different years into a common unit of measurement: the present value. A positive net present value (NPV) is a necessary condition for accepting the project. The NPV has become the main measure of a project's economic value, even though one may find other criteria.[8]

As projects most often only differ in degree in their environmental impact, it is hard to define, and it gives little meaning to talk about "environmental projects". Instead, we shall discuss the impact on the environment of discounting for some relevant groups of project. We first consider a simple purification project, aiming to reduce the emission of a harmful waste. For simplicity and to illustrate the main points, we assume continuous time and infinite time horizon. The investment costs equal 1. The environmental benefits (EB) from the project are constant over time. The NPV of this project is

$$(3.1) \quad NPV = -1 + \int_{t=0}^{\infty} EB \ e^{-it} \ dt = -1 + EB/i$$

Should this project be implemented? As (3.1) shows, the answer is crucially dependent on the discount rate: The higher the discount rate is, the lower the NPV, which goes asymptotically towards -1 as i goes towards infinity. The NPV will be negative for any i > EB. For rates lower than EB the long term environmental benefits outweigh the early investment costs.

This simple case illustrates one important characteristic of the economics of environmental problems. A project to clean up the environment is typically characterized by costs occurring now, whereas the benefits due to enhanced environmental quality come later. This *time-lag* between the costs and benefits is essential for the understanding of the economics of the pollution problem.

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[8] There are also other criteria like the internal rate of return (IRR), the benefit/cost ratio and the payback period. None of these are, however, satisfactory from a theoretical view. The most serious competitor to the NPV-criterion is the IRR. The main disadvantage of this is that for mutually exclusive project alternatives the IRR-criterion will not necessarily select the project that gives the highest increase in welfare. Depending on the timing of the costs and benefits, a project may also have more than one IRR (see 3.2).

In these cases where we have projects with a clear distinction in time between the costs and the benefits, and the environmental effects occur in the long run, we can clearly conclude that a lower discount rate implies an environmentally better project selection. A lower rate values future environmental costs or benefits higher, increasing the social profitability of environmental conservation.

## 3.2 An investment project with negative environmental effects

In this section we shall look at a somewhat different type of project than above.[9] The project requires some initial investments to produce some development benefits (DB), but the production of these benefits also have some unwanted environmental costs (EC). The initial investment costs are unity. We may think of a hydro power development project. The benefits are the energy produced, and the costs, in addition to the investment costs, are the destruction of a wilderness area that produces environmental goods like recreational services. Consider first the case where the benefits and costs remain constant over time. The net present value is

$$(3.2) \quad NPV = -1 + \int_{t=0}^{\infty} (DB_t - EC_t) \, e^{-it} \, dt = -1 + DB/i - EC/i$$

We note that also in this case we get a unique relationship between the NPV and $i$: The higher the discount rate is, the lower is the NPV. The criterion for acceptance of the project (NPV > 0) is $i < DB - EC$.

But in this case implementation of the project will increase environmental degradation. Lowering the discount rate will have the *opposite* effect on the environment compared to 3.1. Thus, for this type of project, the argument that a lower discount rate preserves the environment does not hold: Environmental degradation is linked to new investments. A lower discount rate would make more investments socially profitable, and increase environmental destruction.[10]

A key point in Porter (1982) is that the development benefits are likely to decrease over time, whereas the environmental costs or preservation

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[9] The discussion is based on Porter (1982).

[10] The question of which discount rate to apply for assessments of new hydro power developments has been a big issue in Norway. Some have argued that the rate should be lower than the normal 7 per cent used for public projects, for example 5 per cent. Many environmental groups have, together with economists, defended the use of the "high" rate of 7 per cent.

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benefits, are increasing over time.[11] Let $EC_t$ be the environmental costs or preservation benefits at time t, and $\alpha$ be the exponential growth rate of these costs: $EC_t = ECe^{\alpha t}$. $DB_t$ is the development benefits at time t, and $\beta$ the rate at which the benefits are declining over time: $DB_t = DBe^{-\beta t}$.

When we introduce the changes over time in the development benefits and environmental costs, we get

(3.3)  $NPV = -1 + DB/(i+\alpha) - EC/(i-\beta)$

In this case, there may be no unique relationship between the NPV and i. This is illustrated in fig. 3.1. For high discount rates the project will not pass the NPV-criterion because the initial costs are too high compared to the future (highly discounted) benefits. The project may also fail for sufficiently low rates. This is due to the exponentially growing environmental costs (or benefits of preservation). At the same time, the development benefits are declining, so they cannot outweigh the costs. Thus, there is an interval of discount rates for which the project may be socially profitable.[12]

Related to the environmental critique discussed in chapter 2, we note that the expected increase in the environmental costs has exactly the same effect as a reduced discount rate for these costs. By proper evaluation, taking into account that environmental costs (preservation benefits) are likely to increase over time, the CBA may meet the environmental critique raised against discounting. This illustrates an important point, viz. that (1) the shadow prices and (2) the discount rate used in CBA cannot be looked at in isolation. (See Sandmo (1983) for a more general discussion.)

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[11] "A fundamental asymmetry is perceived in these time paths. Development of wilderness is seen as the extraction or production of physical product which exhaustion or technical advance will probably render less valuable as time passes. Wilderness preservation, on the other hand, is seen as the provision of services with — by the nature of wilderness — a quite inelastic supply curve that is shifting steadily inward as a result of encroachment and congestion" (Porter, 1982, p. 61). In addition, the benefits of preservation are likely to increase as environmental goods are likely to be income-elastic and tastes seem to change in favour of increased appreciation of pure and clean environments.

[12] The shape of the curve is dependent on DB, EC, $\alpha$ and $\beta$. A necessary condition for the pattern shown in fig. 3.2 is that $\sqrt{DB} > \sqrt{EC} + \sqrt{(\alpha+\beta)}$. This is also a necessary, but not sufficient condition to get NPV > 0, and therefore the most interesting case. See Porter (1982) for further discussion.

## Fig. 3.1

The net present value (NPV) at different discount rates for an investment project with declining development benefits and increasing environmental costs
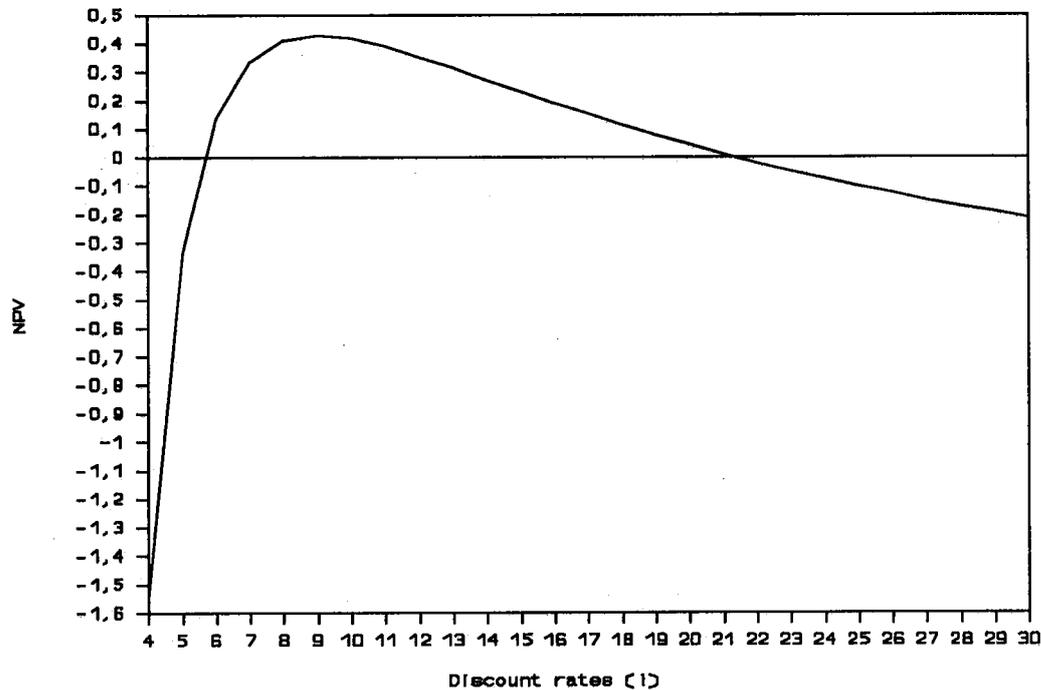


Discount rates (%)

DB = 0.4, EC = 0.1, $\alpha$ = 0.05, ß = 0.02

We can conclude that in the case of investment projects with negative environmental effects which remain constant over time, a lowering of the discount rate may increase environmental degradation. If we assume the environmental costs to decline and the development benefits to increase over time, the effect may be ambiguous. For low levels of the discount rate a lowering of the rate will promote environmental conservation, whereas the effect is the opposite for higher levels.

## 3.3 Extraction of resources

The basic proposition in the theory of exhaustible resources, derived from the Hotelling rule, is that a reduction in the discount rate leads to greater conservation of the resources. The resource rent from extraction grows at a rate equal to the rate of discount. A higher discount rate implies, *ceteris*

*paribus*, a more rapid rise in the price path, which entails lower prices and more rapid extraction in the early periods. "The economic case for rapid development and exploitation of our mineral and fossil fuel resources is enhanced by the use of a high discount rate. This is because the higher the discount rate, the lower the value that the resources will have if left for future development" (Lind, 1982, p. 7. See also Dasgupta and Heal, 1979, and Dasgupta, 1982a, for a discussion of this effect.)

There may be situations where this basic rule does not hold. Farzin (1985), basing his arguments on an analytical discussion, and Stollery (1990), using a simulation approach, argue that this proposition is not generally valid. Farzin shows that the relationship between the discount rate and the rate of resource depletion depends on the capital requirements for both the production of the substitute and the extraction of the resource, as well as the size of the resource stock. A reduction in the discount rate brings about two counteracting effects: "A reduction acts to postpone the use of resources to the future (a conservation effect), and second, ..., it lowers the unit costs in both the substitute and resource sectors and hence induces a faster rate of depletion (a disinvestment effect)" (p. 847). He notes that this latter effect has been completely neglected in the literature.

The depletion of the resource may increase when the discount rate is lowered either when the resource stock is very low, or when the stock is sufficiently high. For large resource stocks, the price will be determined by the marginal cost of production as with ordinary products. A reduction in the discount rate renders the resource cheaper, and increases its use. One may argue that from an environmentalist's point of view, the case with large resource stocks left is not the most interesting one. However, one may get the same effect with a lower discount rate for sufficiently low stocks. The argument goes as follows: "When the stock of the resource is very small, the resource can enjoy a scarcity rent almost as large as the difference between the cost of producing the substitute and its own extraction cost, implying that it will command a price roughly equal to the production cost of the substitute. In this case, a reduction in the interest rate reduces the cost of the substitute, and hence the price obtainable by the resource, leading to a faster use of the resource" (Farzin, 1985, p. 850). This case may be particularly relevant for economies with poor natural resource endowments.

Stollery uses a simulation model to analyze the effect of changes in the discount rate on the extraction of coal and copper. He finds that for the realistic range of rates the discount effect is more or less neutral on the optimal rate of extraction. He also notes that for low discount rates the traditional result tends to hold, while the higher the discount rate, the more

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probable it is that the disinvestment effect will dominate over the conservation effect. For the two minerals Stollery studied, the switch point is at rates between 9 and 10 per cent.

In the case of renewable resources, like fisheries and forests, the arguments are similar to the ones for exhaustible resources. A sustainable use of renewable resources requires that the rate of harvesting do not exceed the biological rate of growth or natural regeneration. However, "it is possible, if the discount rate rises above the maximum biological growth rate of the stock, that, under certain conditions, the resources will be depleted and extinguished altogether" (Pearce et al, 1989, p. 144, see also the standard reference on the subject — Clark, 1976).

Whether a discount rate higher than the biological growth rate leads to a depletion of resources, depends, *inter alia*, on the cost structure of the harvesting. If the costs of fishing the last fish or cutting the last trees are sufficiently high, the resources will *not* be depleted. Renewable resources may also serve important ecological functions. For instance, forests provide flood-protection for agricultural production. If these external effects of cutting trees are included in the cost-benefit analysis, a discount rate higher than the natural regeneration may still not produce an economic justification for a rate of harvesting higher than the biological growth rate of trees.

The main conclusion in the literature is that a higher discount rate will lead to lower stocks of renewable resources. If the rate is above the biological growth rate, the stock may be lower than the one producing the maximum sustainable yield (MSY). In extreme cases, where the marginal cost curve is relatively flat and there are small negative external effects[13], the resource may be extinguished altogether. However, also when it comes to renewable resources, one may have a disinvestment effect which makes the relationship in some cases ambiguous.

## 3.4 Investment level and economic activity

Besides determining the composition of the optimal investment package, the discount rate also influences the optimal level of total investments. A lower rate will let more investment projects pass the NPV-criterion. Thus, high rates will "slow down the general pace of development through the depressing effects on investment. ... the demand for natural resources is generally less with high discount rates than with lower ones" (Markandya and Pearce, 1988, p. 3).

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[13] Alternatively, the external effects are large, but appear far into the future.

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The argument that economic growth has adverse effects on the environment is frequently used by environmentalists. This is a complex issue, but historically economic growth has lead to both increased use of natural resources, as well as increased waste production. This should clearly be the first order effect. On the other hand, the Brundtland-commission (WCED, 1987) argues that poverty in the developing countries is in itself contributing to unsustainable development, and that economic growth may contribute to the solution of environmental problems.

Technical progress is closely linked to new investments. Some argue that economic growth through a high level of investments may more than outweigh the negative environmental impacts that economic growth in itself may have. Whether this view is correct or not, is an empirical question. Historically there is little evidence to support this position, though the correlation between economic growth and environmental deterioration is far from stable.

In a perfect, first-best economy, the level of investments is determined by the discount rate. However, particularly for developing countries, other factors may be more important, e.g. the availability of capital. If the capital constraint is the critical one, then the effects on "the general pace of development" will be insignificant following a change in the discount rate.

## 3.5 Overall impact of discounting

While it is clear, by definition, that discounting in itself discriminates against the future, the effects of lower discount rates are ambiguous, contrary to popular beliefs. For some types of projects, e.g. investments in purification systems, where there are initial investment costs, and long term pay-offs in terms of increased delivery of environmental services, a lower discount rate would increase the probability for projects to pass the NPV-test. Some may argue that this represents the most interesting case when it comes to environmental problems.

For other types of investment projects, where there are (long term) negative environmental effects of the generation of (short term) benefits, the effects of a lower rate is not clear. It depends on the change in the environmental costs and development benefits over time, as well as the level of the discount rate itself. Again, one may argue that in the interesting interval of discount rates the impact is less environmental deterioration, but this requires further empirical investigation. If the change in the benefits and costs over time is small, then projects with negative environmental effects are more likely to be accepted at lower discount rates than at higher ones.

Regarding extraction of resources, the effect may also be ambiguous, even though the general proposition of a positive relationship between the level of the discount rate and environmental degradation may hold. The disinvestment effect should in any case not be overlooked, either the effect on the composition of projects selected or on the overall investment level.

A tentative conclusion would be that the environmental effects of discounting are ambiguous, but that the net effect of a lower discount rate is likely to be positive for the environmental quality. This deserves two remarks. First, the overall goal of a cost-benefit analysis is not to select projects with the lowest environmental impacts. The core of the problem is to find the optimal balance between increased consumption and environmental conservation, or more generally: to find the optimal combination of the various services provided by the environment. Second, the question still remains whether adjusting the discount rate is the most appropriate way to deal with the negative environmental effects in a cost-benefit analysis. The ambiguous relationship between the level of the discount rate and environmental degradation already suggests that this would not be a very precise means if one wants to put more emphasis on environmental conservation.

# 4  Theoretical arguments for discounting

## 4.1 The social rate of time preference

A discussion of the arguments for discounting raises several problems. The literature is anything but clear, and there exists little consensus on the subject. Different theories lead to different conclusions, and the positions are hard to compare as the assumptions and approaches differ considerably. According to Dixon and Meister (1986, p. 41), discounting is "one of the most misunderstood concepts in economic analysis". Two decades earlier, Baumol (1968, p. 788) similarly noted that "few topics in our discipline rival the social rate of discount as a subject exhibiting simultaneously a very considerable degree of knowledge and a very substantial level of ignorance". In the theoretical literature, complex models are developed to find the appropriate rate, whereas in practical situations one finds rather pragmatic judgements. The issue of discounting also involves questions of intergenerational justice and equity. This raises more fundamental questions on the philosophical basis of welfare economics.

The discussion here is in no way a complete survey of the approaches found in the literature. We have selected a few approaches that may provide

a useful framework for the issues we want to highlight. In a subsequent section, we also discuss a few more fundamental problems on the rationale for pure time preference.

The first part of the discussion is based on the framework used in Social Cost-Benefit Analysis (SCBA) (Little and Mirrlees, 1974; Squire and van der Tak, 1975; Ray, 1984; Pedersen, 1988; Fjeldstad, 1989; Brent, 1990).[14] Compared to traditional CBA, this approach pays explicit attention to the distributional impacts of a project, and how consumption changes for different groups are to be valued. This approach allows for an explicit discussion of both the inter- and intragenerational distribution within the same framework. Indeed, many of the same considerations that apply to the distribution issue at a particular point in time, also apply to the distribution between individuals over time. We will limit ourselves to a discussion of the intergenerational issue, which is the most relevant one for this paper.[15]

Our starting point is the objective of economic policy — to maximize the welfare of the society. This is represented by a dynamic social welfare function (W), which is simply the discounted value of the welfare in each period ($W_t$). The discount rate is the rate of pure time preference (p), assuming $p \geq 0$.

$$(4.1) \quad W = \int_0^\infty W_t \, e^{-pt} \, dt$$

According to the Bergson-Samuelson welfare function, $W_t$ is a function of the individual utilities in each period. As we are not interested in the distribution within each period, we introduce a representative consumer with an utility function, $U(C_t)$. This makes $W_t$ a function of only his

[14] The model used in 4.1 has a much wider use that just in SCBA, particularly in optimal growth models. Its roots go back to Eckstein (1957).

[15] The intragenerational distribution may, however, also be relevant. For most projects with substantial environmental effects the costs and benefits are asymmetrically distributed: The costs may be borne by one group of people, whereas the benefits are enjoyed by another. In many cases in poor countries, the costs of environmental degradation are borne by the rural and poor people, whereas a richer, often urban, elite are reaping the benefits. The environmental degradation has not only an important aspect of intergenerational distribution, but also of distribution within the present generation. SCBA, which gives higher social weights to a $1 extra to the poor than to the rich, will in these cases give higher weight to the negative environmental effects. Using the SCBA instead of the traditional CBA will, therefore, contribute to better environmental performance of public policy.

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consumption in period t $(C_t)$.[16] For additional simplicity, we use a function which is constant over time and with constant elasticity of marginal utility.

$$(4.2) \quad W_t = U(C_t) = (1-n)^{-1} C_t^{1-n}, \quad \text{for } n \neq 1, n \geq 0$$
$$\quad \ln C_t, \quad \text{for } n = 1$$

The marginal utility, i.e. the increase in period t welfare due to one extra unit of consumption in period t is

$$(4.3) \quad W_{tc} = U_c = C_t^{-n}$$

n is the elasticity of the marginal utility or welfare of consumption.[17] This is a key parameter in the discussion, and is also at the centre of the SCBA, both for the inter- and intragenerational issues. n = 0 implies that the welfare increase of one dollar extra income to the consumer is the same regardless of his initial consumption, i.e. whether he is rich or poor. There is no weighting of consumption increases with respect to the consumer's level of utility. For the intragenerational case, this corresponds to the traditional cost-benefit approach.[18]

Any n > 0 indicates a preference for a more equal distribution of income, and the higher n is, the stronger are the preference. Particularly, one should note the case where n = 1 — the Bernoulli case. Then the welfare value of a given consumption increase for an individual will be inversely proportional with his consumption level. The value of one dollar to an individual with an income of $ 100 is worth 10 times more than the same increase to someone with an income of $ 1 000.

Using (4.1) and (4.3), we can now find the (discounted) welfare effect of a marginal increase in the consumption in period t.

$$(4.4) \quad W_{ct} = C_t^{-n} e^{-pt}$$

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[16] One problem discussed in the literature, with little consensus, is the specification of the welfare function and its implication for the social rate of discount when the population is growing. This is particularly relevant to developing countries. Our specification ignores the size of the population that exists at any point in time. See for example Layard (1972), Dasgupta (1982) and Brent (1990) for a discussion.

[17] The elasticity of the marginal welfare or utility of consumption is: $U_{cc} (C_t/U_c) = -nC^{-n-1}$ $C_t C_t^n = n$.

[18] The use of distributional weights in CBA is a controversial issue, see particularly Ray (1984) for an argument in favour of including distributional impacts in the analysis, and Harberger (1971, 1979) for the opposite view.

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The consumption rate of interest (CRI) is defined as the rate at which the marginal welfare of consumption ($W_{ct}$) falls over time:

(4.5)   $CRI = - (dW_{ct}/dt) / W_{ct}$

From (4.4) and (4.5) we obtain[19]

(4.6)   $CRI = i = ng + p$

g is the growth rate of consumption (for our representative consumer), and we assume that g > 0, i.e. we expect some economic growth. The CRI or i is the social rate of time preference, and also the social rate of discount in this model.[20]

According to (4.6) we have two basic reasons for discounting. First, we place less weight on future increases in consumption simply because our representative consumer has become richer. Because n is assumed to be positive, an increase in the consumption of a rich consumer entails lesser increase in welfare than the same increase to a poor consumer. Discounting is necessary to avoid a redistribution of income from a present generation that is relatively poor to a relatively rich one in the future.

This reason for discounting is parallel to the one used when discussing intragenerational distribution in SCBA. The discussion on inter- and intra-generational distribution is closely linked — both are related to our preferences for consumption increases to the poor. We should particularly note that strong preferences for a more equal distribution among individuals today (high n), also implies a strong preference for consumption now rather than in future periods. The reason is simply that if we generally give a relatively high value to consumption increases to the poor, the poor in an intergenerational perspective, is the present generation, not the future ones (as long as g is positive).

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[19] The derivation of the CRI-formula in more details goes as follows:

$-dW_{ct}/dt = pC_t^{-n} e^{-pt} + nC_t^{-n-1} e^{-pt} (dC_t/dt) = C_t^{-n} e^{-pt} [p + nC_t^{-1} (dC_t/dt)]$

Inserting this and (4.4) into (4.5) produces

$CRI = [C_t^{-n} e^{-pt} (p + nC_t^{-1} (dC_t/dt))] / [C_t^{-n} e^{-pt}] = p + n C_t^{-1} (dC_t/dt)$

If we define $g = (dC_t/dt)/C_t$, we get (4.6).

[20] A discount rate is generally defined as the decline in a variable over time. This section may illustrate the importance of the choice of numeraire for the level of the discount rate. In the formulation in (4.1) welfare was used as the numeraire, and the corresponding discount rate was the pure time preference. (4.6) gives the appropriate rate of discount when we use consumption of a representative consumer in each period as our numeraire.

The second reason for discounting is the pure time preference. p > 0 implies that we have some impatience, and would prefer early consumption to later consumption, even if the consumption level is the same. We shall return to a discussion of this concept in 4.3.

The advantage of this framework is that it separates the issue of diminishing marginal utility and (pure) time preference. Olson and Bailey (1981) "strongly suggest that "positive time preference" be defined to exclude the effects of a difference in marginal utility due to any lower level of consumption in the present and, therefore, to include only the preference for present over future consumption due to other causes" (p. 5). Unfortunately, the concepts are not uniformly used in the literature. In the following, we will use the term "*pure* time preference" when referring to "p", and "social time preference" to include both the pure time preference and the effects of diminishing marginal utility. This will correspond to the term used by in the literature on which we are basing the discussion.

We have summarized the different cases from formula (4.6) in table 4.1. We have assumed diminishing marginal utility (n > 0) and a non-negative pure time preference (p ≥ 0), which should be generally acceptable.

Table 4.1
Different cases of CRI (CRI=i=ng+p)

|       | p > 0 | p = 0 |
|-------|-------|-------|
| g > 0 | i > 0 | i > 0 |
| g = 0 | i > 0 | i = 0 |
| g < 0 | i ?   | i < 0 |

We see that the distinction between diminishing marginal utility and pure time preference is important. A positive rate of discount does *not* imply positive time preference. Moreover, the case for negative discount rates can only be justified within this framework if we expect negative growth, sufficiently high to outweigh a possible positive pure time preference.

There is nothing within this framework that suggests that environmental considerations should lead to a lower discount rate generally or for certain costs/benefits, *per se*. There may, however, be arguments from the environmental debate that could indirectly influence the level of the discount rate. First, the rationale for discounting due to pure time preference has been questioned (4.3). Further, it is also suggested that

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increased environmental problems either will, or should, lower economic growth, which implies a lower g. If this is correct, then the existence of environmental problems should lower the expectations for future growth, and according to our model also lead to a lower social rate of discount.

## 4.2 The social rate of discount and the private capital rate of return

In the previous section we found two arguments for discounting: Pure time preference and diminishing marginal utility of consumption. A third commonly used argument for discounting is the existence of a positive rate of return on investments in the private sector, or capital productivity. It has also been argued that this rate or a weighted average of CRI and the private return, is the appropriate social rate of discount.

The argument for considering the rate of return in the private sector is that this represents the opportunity cost of funds used in public projects. Using a rate lower than the private sector's would approve public projects in cases where resources could have been allocated to private sector investments with higher yield. On the other hand, according to the social time preference, the society is willing to allocate resources to the future, using a discount rate lower than the private sector rate of return. This contradiction is the focus of Baumol (1968), who regrets that "no optimal rate exists. The rate that satisfies one requirement cannot possibly meet the conditions of the other" (p. 798).[21]

We should note that in our formulation of the maximation problem in (4.1), it is only the stream of consumption that counts. Investment — both public and private — is simply a means of transforming potential consumption in one period to another period, and it is only this way that it influences our valuation of a project. In comparing one situation with, and another without the project, we need only to compare the streams of consumption in the two situations, or actually only their present values. If all the effects of a particular project have been translated into consumption changes at every point in time, the framework used in 4.1 should be the correct one, and the social rate of time preference is the discount rate to be used.

The problem, however, is that we normally do not trace all the effects into changes in consumption. Usually only the direct effects of a project are

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[21] In a perfect, first-best economy the rate of return on private investments would be the same as the consumption rate of interest.

considered, and there is little reason to assume proportionality between the direct effects and the total effects on consumption. A public project will, typically, change both private consumption and investment. In its first investment period the project is likely to have some crowding out effects on private investments, whereas the benefits produced in the following years may increase investments. These changes in private investments in turn change the consumption pattern over time. Because of the difficulty of determining all these effects and transform everything into consumption streams, the practical procedure has been to look at the direct effects, i.e. to add up both consumption and investment effects. This means that we have to change the numeraire used in CBA, which generally also implies changing the discount rate.

The literature suggests some ways out of the dilemma noted by Baumol. Within the tradition following Arrow's (1966) work, the solution is to make the optimization problem explicit, including the constraints facing the government. The problem is formulated in relation to optimal economic growth. The selection of the discount rate is a part of this problem, and an outcome of the solution. Thus, the optimal rate will generally depend on, *inter alia*, the source of financing and the macroeconomic policy in general. This also implies that the discount rate should differ between projects.

Another solution to this apparent dilemma has been developed by Bradford (1975). He assumes a second-best world, where the government is restricted in its investment opportunities in the way that investment in the private sector is *not* an option. "Because of such restrictions, apparently attractive returns in the private sector may not represent opportunity costs for the government, or at least not directly. ... private rates of return become irrelevant to government choices" (p. 888). However, the private rates of return play an indirect role in the assessment of public projects, as will be clear later. We shall briefly present the model developed by Bradford, see also Lind (1982) and Hagen (1983). This allows us to separate consideration of (1) the social time preference, and (2) the effects of public projects on private investment (the private sector rate of return).

We consider a public investment project, with all costs incurring in period t and all benefits in period t+1. Bradford extends his analysis to public investments with multiperiod returns, but this does not add any fundamental insight to the problem.[22] The important point is that we also include effects on private sector consumption and investment *after* period t+1, caused by the project costs (period t) and benefits (period t+1).

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[22] Compared to Bradford's model, we have for simplification also assumed all the variables to be time-independent.

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The investment costs are \$1 in period t. The project yields its entire output \$(1+\mu) in period t+1. $\mu$ is the rate of return on public investments. Let a be the decrease in private investments due to a \$1 increase in public investments costs, making (1-a) the loss in private consumption in period t.[23] Further, we define v as the social value or shadow price of private investments, i.e. the discounted value, using the social rate of time preference (i), of all the consumption changes due to a \$1 change on private capital. Thus, the present value of the decrease in private investments is av, making the total consumption loss (1-a+av), valued in period t consumption units.

The benefit of the project, an output of (1+\mu) in period t+1, causes an increase in the consumption in period t+1 of $(1-\alpha)(1+\mu)$, where $\alpha$ is the increase in private investments due to a \$1 increase in the output in the public sector, and $(1-\alpha)$ the equivalent increase in private consumption. The increase in private investments causes, indirectly, a change in the consumption in all future periods. The value of this increase is $(1+\mu)\alpha v$. Discounting to period t values, the total benefits of the project are $[(1+\mu)/(1+i)]$ $(1-\alpha+\alpha v)$. The net present value of the project then becomes

(4.7)   $NPV = -(1-a+av) + [(1+\mu)/(1+i)]\ (1-\alpha+\alpha v)$

The NPV is positive if and only if

(4.8)   $(1+\mu)\ /\ (1+i)\ >\ [1-a(v-1)]\ /\ [1+\alpha(v-1)]$

This formula determines the rate of return, $\mu$, that is required to make the project profitable. Generally, the critical rate is a function of i, a, $\alpha$ and v. We are now looking at some different cases corresponding to various assumptions about the parameters.

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[23] We assume full employment of resources, implying that all resources used in the public sector are drawn from the private in a 1:1 relationship. This may be an unrealistic assumption for many developing countries, particularly in cases where the unemployment rates are 30-40 per cent. If the costs of a public project do not reduce the private consumption and investment with the same amount, it is clear that the required rate of return will be lower for the project to pass the NPV-test. Thus, if public projects are able to mobilize unutilized resources, the requirement on the rate of return should be lowered.

*Case A: a=α=0*

This is the simplest case where the public project does not affect private investments at all. The direct effects on private consumption equal the total effects. The appropriate rate to use is the social time preference. This may be an extreme case, but is a point of reference and has parallels to the model discussed in 4.1.

In a discussion of the implications of the increased international mobility of capital on the discount rate, Lind (1990) argues that the effects of a public project on private investments may be insignificant. This indicates that this case may be realistic in the presence of a high degree of capital mobility.


*Case B: a=α*

This more general case says that there is some symmetry in the way costs and benefits affect private investments: $1 cost and $1 output causes the same change in private capital formation. This case may be a realistic one, for example if the "revenue is raised by direct taxation of consumer citizens and in which the implicit income from the government project is treated exactly like ordinary, after-tax, income" (Bradford, 1975, p. 890).

From the formula in (4.8), we easily see that the acceptance condition simply becomes $\mu > i$, i.e. the project should be accepted as long as the marginal rate of return exceeds the social time preference rate. This is a rather remarkable result, and, as Bradford notes, "the surprising aspect of this case is that the rate of return in the private sector, sometimes called the opportunity cost of funds, does not enter the equation at all" (p. 891).


*Case C: a=1, α=0*

In this case, all the resources used as inputs in the project are drawn from private investments, whereas the entire output goes to increased consumption directly and does not affect the private capital formation. Bradford notes that "these assumptions ... are often made, at least implicitly" (p. 891). The condition for a positive NPV is now:

(4.9)  $(1+\mu)/(1+i) > v$

v is realistically a number greater than 1.[24] The required yield is therefore greater than the social time preference. Bradford further shows that given that v, i, r and the rate of saving are constant, this requires that the rate of return on the public project must also be *higher* than the private rate of return. The reason is that "the government project does not generate the favourable repercussions on future capital formation which the private investment does" (p. 891).

## Case D: a=0, α=1

This is the opposite of case C: All the resources are drawn from consumption, and the yield converted into private capital. The condition for NPV > 0 becomes

(4.10)  $(1+\mu)/(1+i) > 1/v$

In this case, the required rate of return will be lower than the social time preference, because the government in this case generates favourable repercussions on private capital formation.

## Case E: The two-period model: α=0

Using a two-period model, letting the second period represent the future, has been a common method to analyze the question of discounting. A two-period analysis means that there is no investment in the second period, i.e. α=0. One unit of forgone capital in period t gives a reduction in consumption in period t+1 of (1+r) units. The social value of private capital then simply becomes $v = (1+r)/(1+i)$. This produces the following conditions for the required rate of return:

(4.11)  $\mu > (1-a)i + ar$

To be accepted, the rate of return of the public investment must exceed the weighted average of the social time preference and the rate of return on private capital. The weights are the proportions in which the resources are being drawn from consumption and investments in the private sector. (4.11)

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[24] Bradford finds v to be in the range of 0.96 to 1.19 under a realistic range for the values of the parameters.

is perhaps the most common recommendation in the literature on how the social rate of discount should be determined, see for example Sandmo and Drèze (1971), who use two-period models to arrive at this formula.

In this framework the two-period model and the consequent recommendation is just a special case, with the rather unrealistic assumption of no future capital formation consequences of changes in either government or private investment. In general, as we have seen, the appropriate rate may lie even outside the borders of the social time preference rate and the private rate of return. This conclusion is also derived by Stiglitz (1982), who uses a somewhat different approach.

The optimal discount rate for the public sector is based on opportunity-cost reasoning. The profitability of a public project should be determined on the basis of the alternative uses of the resources, thus the attention to the uses from where the resources are taken, and where the outputs are going. If we adopt the approach outlined above, there will be no single social rate of discount, but different rates for different projects. The rates may even differ for the same project depending on how it is financed and the state of the economy when it is implemented.

There are considerable problems in estimating the effects of a public project necessary to calculate the optimal social rate of discount. Thus, we have good reasons to consider some sensible rules of the thumb. Bradford suggests to use the social rate of time preference, i.e. that case B is a realistic one. $a=\alpha$ is known as the Arrow-Kurz assumption. Lind's (1982) advice is to use an approach in which "we adjust benefits and costs at each point in time so that they are expressed in terms of consumption equivalents, which can appropriately be discounted using the social rate of time preference" (p. 44), as we have outlined in 4.1. He argues that this method does not require more information than the other one.

How can the environmental debate be fitted into this framework? We have an argument for using a discount rate lower than the social rate of time preference if (and only if) $a < \alpha$. Projects where the investment costs have small crowding out effects on private investments (low a), and where the benefits generated stimulate private investments in the future (high $\alpha$) should be discounted at a lower rate.

Based on the above discussion, it seems difficult to find a general argument for using a lower discount rate on projects with large environmental consequences. Consider, for example, an investment in a purification system that will produce a better environmental quality in a recreational area, i.e. increase the consumption of recreational goods. In this case it is likely that $\alpha$ will be small (and $a > \alpha$). Thus, we have an argument for using a discount rate *higher* than the social time preference. On the

other hand, consider a purification project that cleans up waste that is a (negative) input in another production process. It is more likely that $a < \alpha$ in this case, and we may have an argument for a rate lower than i. Thus, it seems difficult to find any general arguments within this model that favour the use of a lower discount rate for projects with large environmental effects.

## 4.3 Should positive pure time preference be allowed to influence the social discount rate?

We have seen in the previous sections that there are good arguments for using the social rate of time preference as the social rate of discount, even if we calculate the effects directly. In the case where all effects are transformed to consumption equivalents, it is obvious that this is the rate to be used. We shall now focus on the pure time preference, which is the argument for discounting that does not originate in diminishing marginal utility.

In economic textbooks, a positive time preference is often referred to as just "impatience" or "pure myopia". If a consumer has the option of getting a cake today or tomorrow, he would prefer getting it today. Myopia may be regarded as just a part of human nature; "as a brute fact about human psychology, this seems undeniable" (Goodin, 1982, p. 54).

An argument for "the case for positive time preference is absolutely compelling" is given by Olson and Bailey (1981), to be referred to as O-B. Their starting point is a consumer who maximizes his intertemporal utility, given the budget constraint. The utility function for our representative consumer is similar to the welfare function presented in 4.1. We assume that the consumer is not constrained in the credit market, and he is free to borrow or save at the same rate of interest (r).

The major outcome of this optimization problem is well known from the more general intertemporal theory of the consumer behaviour. Using our specification of the welfare function (4.2), optimization implies

$$(4.12) \quad C_t^{-n}/C_0^{-n} = e^{pt}/e^{rt}, \quad t = 1,\ldots \infty$$

If we assume, for simplicity that n = 1, we get

$$(4.13) \quad C_0/C_t = e^{pt}/e^{rt}, \quad t = 1,\ldots \infty$$

This simple formula generates a number of interesting results. First, we note that a necessary condition for constant consumption over time ($C_t = C_0$) is that the rate of interest equals the rate of time preference ($r = p$). Second, if $r > p$, which may be fair to assume, then we get increasing consumption over time. The return on putting money in the bank is higher than the pure time preference, so the consumer is better off doing so. But because of diminishing marginal utility he will reach a point where the gain of increased future consumption through more savings/investments is not compensated for by the sacrifice of present consumption.

Let us now consider the implications of the case of zero time preference, and a positive rate of interest. When expanding the time horizon to infinity, we get from (4.13)

$$(4.14) \quad \lim_{T \to \infty} C_0/C_T = 0$$

According to this model, a zero time preference and an infinite time horizon imply that the consumer will reduce his present consumption level to zero.[25] This result may be somewhat surprising, and O-B "doubt that the proponents of a zero time preference and an infinite time horizon have understood the implications of their argument" (p. 13). The quest for intergenerational justice is not solved by zero time preference. A stable level of consumption implies, as noted earlier, that $r = p$.

What happens if we replace the infinite time horizon with a finite one in the consumers problem? "Truncating a decision maker's time horizon can (...) only strengthen the evidence for a positive time preference, since it merely involves attributing zero value, rather than a discounted, but positive value, to any consumption after a certain date" (p. 14). In general, the case for positive time preference gets stronger as the time horizon gets shorter.

Commenting on the environmental debate, O-B hold that "those who advocate certain environmental and resource policies on the ground that the interests of all future years and generations ought to be weighted equally with our concern for utility in the present, are contradicted by their own behaviour" (p. 3).

This result contradicts another result in economic theory, showed originally by Strotz (1956) and also discussed by Krutilla and Fisher (1975): Individual pure time preference is not necessarily consistent with

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[25] As O-B point out, this is given that "the $C_T$ attainable under the budget constraint is below the satiation level" (p. 12), that is where the marginal utility is zero. In our formulation of the utility function, this possibility is excluded.

lifetime welfare maximization. Consider an individual who makes a plan for his present and future consumption, based on lifetime utility maximation. Would he, when reconsidering his plan at later dates, obey or disobey his original plan? Strotz shows that the original plan will generally *not* be obeyed, even if all his original expectations about the future are verified. Due to his pure time preference, he will get a "spendthrift". At any point in time, he will spend more than he should according to his previous plan.

Strotz notes that this may be particularly relevant for consumers with low income — they spend "too much" now because of high pure time preference. High individual time preference in developing countries seems to be a reasonable explanation of high individual discount rates. When people are poor, and live in a more unstable environment, the risk and uncertainty about the future is higher, including the risk of death. Thus, poverty may to some extent also give a rational justification for the individuals to use high discount rates. Still, this cannot fully explain why poor people seem to have higher individual discount rates.[26]

Then the question now arises: Should *irrational* individual preferences be allowed to determine a *social* decision rule as the discount rate? Several authors have been reluctant to accept "consumer sovereignty" in this case:

> ... irrationality may dictate very high social discount rates with a corresponding small legacy of capital for future generations. That discount rate may therefore be incompatible with some other value judgements being used. Moreover, the very construction of consumer demand theory is based on assumptions which rule out irrational preferences (e.g. preferences which would permit indifference curves to intersect). Why then suddenly take a moral stance which says that this irrationality will be permitted when calculating a discount rate? (Pearce and Nash, 1981, p. 154).

Sen (1961) states that "in so far as the "pure" discount arises merely due to irrationality, its use in a choice that aims at being "rational" is unjustifiable" (p. 482). Goodin (1982) puts it this way: "There is no more reason for public policy to reflect this disability than there is for it to reflect

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[26] Using a model of individual behaviour in the purchase and utilization of energy-using durables, Hausman (1979) finds that the discount rate varies inversely with income in the United States. The estimated rates vary from 89 per cent for the lowest income class ($ 6 000) to 5.1 per cent for the highest ($ 50 000). This is a surprisingly huge range, and the result has parallels in the comparison between rich and poor countries.

people's incapacity to think rationally about large numbers or to perform fancy arithmetic" (pp. 54-55). Strotz himself concludes that "consumer sovereignty has no meaning in the context of the dynamic decision-making problem" (p. 179).

Markandya and Pearce (1988) are also sceptical to this, and illustrate their point with a situation where high discount rates cause environmental degradation, and at the same time "poor prospects arising from environmental degradation actually assist in generating the poverty that 'causes' high discount rates" (p. 35). They argue that using these rates would be wrong: "if high personal time preference rates are allowed to influence the value of i (social time preference rate), the implication may therefore be that the discount rate unjustly reflects constrained activity, a situation where individuals are unable to act in normal economic and environmental framework" (p. 35). Their suggestion is to lower the pure time preference rate in the contexts where the environment-poverty linkages are strong, i.e. to use as the reference point a "normal" situation which the policy is aiming for.

A second argument that is used to explain why people have a positive time preference is uncertainty about the future. This risk and uncertainty can be divided into three groups (Markandya and Pearce, 1988, and Pearce and Turner, 1990):

(1) Risk of death, i.e. uncertainty about the presence of the individual.
(2) Uncertainty about future preferences.
(3) Uncertainty about future benefits and costs.

The "risk of death argument" may be entirely rational from an individual who is risk averse.[27] The risk of death leads to higher individual discount rates, i.e. more consumption now and less later. This general view is not fully agreed upon by Olson and Bailey (1981). They conclude their discussion on the effects of uncertainty claiming that it "may reduce the expected apparent rate of return on saving, yet at the same time in the absence of universal futures and insurance markets it can increase the 'need' or incentive for saving, that is, its prospective utility". In summary, the "risk of death" and the "save for a rainy day" arguments point in different directions, and, therefore, the effects of uncertainty on the time preference are ambiguous.

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[27] Eckstein (1961, quoted in Pearce and Nash, 1981) has calculated such rates for US and India, and derived values of 0.4 and 2.15 per cent respectively for the 40-44 age groups.

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Assuming that the risk of death increases the time preference, the question again arises if "it is illegitimate to derive implications for potentially immortal societies from risks faced by mortal individuals" (Markandya and Pearce, 1988, p. 31). Even though this is rational from the individual standpoint, it seems irrational for the society as a whole to base its policy guidelines on the fact that "in the long run we are all dead".

The two other types of uncertainty may be highly relevant in the case of projects with large environmental impacts, and we will return to a discussion of these issues in chapter 5.2. In conclusion, there are strong arguments for the *existence* of positive individual pure time preference. But this is partly based on irrational behaviour (myopia), and partly on individual mortality and other types of individual uncertainty. The individual arguments for pure time preference are highly questionable when it comes to their influence on the determination of the social rate of discount.

Before completing our discussion on the relationship between individual preferences and the social rate of discount, we shall briefly review the arguments discussed by particularly A. Sen on why these two rates should differ. Sen (1982) uses three arguments for applying a social rate of discount lower than the private one: (1) The "isolation paradox"; (2) the dual-role argument; and (3) the super-responsibility argument.

The isolation argument or "isolation paradox" goes back to Sen (1961) and Marglin (1963), the latter using the term "interdependence argument". This is just a special instance of a very general problem, namely the non-zero-sum game, known as the "prisoner's dilemma" in the two-person case (Sen, 1967). Consider an individual that faces the choice of how much to consume now and how much to save (invest). The return on his saving will depend positively on how much is being saved by others, i.e. there exist positive external effects. The outcome of all the individuals acting in isolation will be that the total saving is too low. However, it is possible to make everybody better off by undertaking more investments collectively than each finds desirable to undertake privately. The reasons for such externalties may be e.g. higher individual risk of a project than the risk imposed on society, and the public good character of investments (Baumol, 1968).

The dual-role argument rests on the assertion that we as individuals play different roles, one as a market actor taking decisions concerning our own consumption, savings etc., the other role being as an actor in a public decision process. "The Economic Man and the Citizen are for all intents and purposes two different individuals" (Marglin, 1963, p. 98). According to this view, the relevant social rate of discount should not be based on

market rates of interest, but rather as the outcome of a political process, i.e. where the individuals act as Citizens. Generally, it is also reasonable to assume that an individual gives higher weight to future generations in his public role. The "impatience" and the "risk of death" arguments discussed earlier may be viewed as examples of the judgements people exercise in their role of the "Economic Man". In their "Citizen" role, however, they may more be hesitant to let their own mortality determine their judgments in public affairs. It may, however, be difficult to distinguish between the isolation argument and the dual-role argument. Some of the opinions expressed in public may be in their self interest only if they are collectively agreed upon.

An argument against using the individual's public role for determining the social rate of discount is that, since we have two different sets of preferences, only one of them can be true. "Since deeds speak louder than words, one can argue that preferences revealed in the market place are more genuine and better considered" (Marglin, 1963, p. 99). If one accepts that the nature of decisions are fundamentally different in the two situations, Marglin's argument is not convincing.

The third argument favouring a lower social rate of discount is the super responsibility role of the state or the authoritarian or paternalistic argument. The state is viewed as an entity with objectives separate from and independent of its individual citizens. The state is a guardian of national interests and future generations, and these go beyond the interests and preferences of the individuals.[28] This argument is related to another one, namely that it is the satisfaction of wants as they arise that matters. "We are interested in tomorrow's satisfaction as such, not *today's assessment* of tomorrow's satisfaction" (Sen, 1957, p. 746). This raises deeper philosophical issues, and questions whether the underlying value judgement in CBA is properly expressed.

## 4.4 Should the social discount rate be lowered?

Assuming that a lower discount rate promotes environmental conservation, should the discount rate be lowered to include environmental concern? In

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[28] This line of argument goes back to Pigou (1932). He argued that the state should be a guardian of interests of future generations as well as the interests of the present one. Thus, the state should use a lower rate of discount in its decisions than the individual citizens do, in order to give more weight to future generations. According to Pigou, social welfare is not only a function of the utility of present members of society, but also of the utility of all future members.

this respect, it is crucial to distinguish between two separate lines of critique: (1) The fact that a project has environmental effects should imply a lower discount rate, and (2) the discount rates presently in use are too high.

Our conclusion on the first question is that the presence of large environmental impacts does not, *per se*, provide any arguments for a lower discount rate for the particular project. This has also general support in the economic literature (see Cooper, 1981, Lind, 1982, Markandya and Pearce, 1988, Pearce et al, 1989). These effects would better be handled in ways described in the next chapters.

Indirectly, there may be arguments for adjusting the discount rate in the presence of large environmental effects. Estimates of the social rate of discount according to the formula in (4.6) are often based on the past performance of the economy, i.e. the past growth rate in consumption. Some environmentalists argue that future growth will be lower due to increased environmental problems and constraints. This is a basic proposition in the "Limits to Growth" argument: Finite stocks of natural resources and limited renovation capacity will lower the rate of economic growth.[29] Increasing resource scarcity would therefore, indirectly, imply lowering the social rate of discount.[30]

As discussed in section 4.2, we have an argument for using a discount rate lower than the rate of social time preference if a general characteristic of public projects with large future environmental consequences is that the investment resources are mainly drawn from consumption, whereas the benefits mainly generate higher private investments. It seems difficult to assume such a characteristic for "environmental" projects. In fact, one could argue that for a typical project the benefits are mainly consumed, whereas the costs today draw resources from other private investments. In any case, to assume such general characteristic seems speculative.

The environmental debate has (again) questioned the validity of individual pure time preferences as a factor determining the social rate of discount. Is positive pure time preference morally defensible? Is it legitimate for the government to reexamine (the consistency of) individual

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[29] Declining per capita consumption has been the situation for a number of developing countries in particularly Sub-Saharan Africa over the past two decades. This trend is partly caused be deteriorating environmental conditions.

[30] Interestingly, the same conclusion may be derived from other approaches. For instance, Moxnes (1989) asks which discount rate would ensure sustainable development, and concludes that the discount rate will be falling over time due to increasing resource constraints on economic activity.

preferences? The influence of individual pure time preference on the social rate of discount is particularly questionable when it comes to decisions that may have large consequences for the well-being of future generations.

Regarding the second question raised on whether the presently used rates generally are too high, it requires a study on its own. Our remarks are limited to some observations on the differences in the underlying arguments behind those rates being used, compared to the discussion in this chapter. As shown, it may be hard to justify some of the arguments normally used for high discount rates. This concerns the opportunity cost in the private sector. The influence of the private return on the social rate of discount is, as showed in section 4.2, dependent on whether it is the direct effects of the project or the total consumption effects that enter the calculation. In the latter case the private return should have no influence on the social rate of discount. Further, and may be more important, the use of pure time preference as a reason for discounting was questioned.

There is one strong argument for discounting, viz. the diminishing marginal utility of consumption. This raises the question of what the elasticity of the marginal utility (n) should be, as well as the (expected) rate of growth in consumption. The Bernoulli-case (n=1) seems to be widely used, but in general n will vary with both the income level of the country concerned[31] and the society's (government's) preferences for a more equal distribution. If one takes the critique against pure time preference seriously, and assumes that n=1, we would arrive at social discount rates that equal the rate of growth of consumption. This would, indeed, give discount rates much lower than those presently used.

Several authors have also criticized the level of the discount rates. Cooper (1981) comments on this question in the following way:

> After all, economics has not been able to offer any empirical evidence on the social rate of discount. For the most part, discount rates reflect value-judgements made by planners. They are no doubt influenced by 'fashion'; it is comforting to know that one is discounting at a rate which is reasonably close to the rates that other people have used. They are probably also influenced by market rates of interest, even though there is not much reason to suppose that market rates reflect social time preferences. The 'conservatism' that leads to the use of social rates of

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[31] For developing countries, one can argue that for consumption levels near the level of survival, the marginal utility becomes very high. Thus, we may have an argument for higher n, the poorer people are. This is to say that people value consumption now as they are very poor much higher than later consumption when they have become richer (less poor).

discount which are lower that the market rates of interest, but not by 'too much' has little basis in logic (p. 99).

He further states that "there are arguments to support the idea that "normal" discount rates (say from 5-10 per cent) are too high", and that one of the reasons may be that planners base their judgements on individual preferences and do not take account of the "isolation paradox". Cooper is also referring to the argument that the very fact that people are concerned about long-run environmental costs "may in itself be taken to show that people's concerns about costs and benefits to future generations are more considerable than discount rates actually used would suggest" (p. 99). This argument has some relevance, but the current environmental concern should better be interpreted as an indication that many people want a change in policy. Then, the next question is to find the best way to accommodate this concern in the project and policy appraisal methods.

Lind (1982) argues that the level of the rates commonly used today, namely "a discount rate of 10 per cent in constant dollars will (if 10 per cent is above the social rate of time preference) lead to a systematic underestimation of the costs of government programmes that involve current consumption, and will incorrectly bias the analysis against government expenditure that will produce benefits that will flow back into the economy in the future". This bias will not be present in the approach suggested, which "provides us with a conceptual basis for correctly calculating the opportunity cost for all public expenditure programs, not just public investments" (p. 55).

Berlage and Renard (1985) and Brent (1990) also discuss the conceptual basis for the discount rate, particularly when applied to projects in developing countries. Their argument is that the rates presently used by international agencies like the World Bank are too high. The following passage between Little and Mirrlees, the authors of the standard manual on "Project Appraisal and Planning for Developing Countries" illustrates that pragmatic considerations have played a major role. Little explained: "... I said to Professor Mirrlees that we should find a way of producing an interest rate that the World Bank would believe. They always want 10 per cent or more, and most economists have been talking in terms of a social discount rate of more like 4 or 5 per cent. The World Bank would not find that credible. So the answer was to change the numeraire" (quoted in Berlage and Renard, 1985, p. 691).[32]

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[32] Little and Mirrlees (1974) and Squire and van der Tak (1975) use uncommitted foreign exchange in the hands of governments as the numeraire in their analysis, not

# 5   Expanding the traditional CBA

This chapter briefly reviews some of the extensions of the traditional CBA that have been suggested in order to take proper account of a project's environmental effects. These techniques have, by and large, been developed during the last two decades. They are well founded in economic theory, but raise, however, significant problems of estimation and practical implementation.

There are usually four different types of values attached to the environment:

(1) *Use value* refers to the economic value derived from using the environment in one way or another;

(2) *Option value*, which may be defined as a risk premium when there is uncertainty of future demand and/or supply of environmental services.

(3) *Quasi-option value*, which is the value of preserving options, when decisions are irreversible, future costs and benefits uncertain and the information on the costs and benefits increases over time.

(4) *Existence value*, i.e. the value of just knowing that something exists.

Our emphasis will be on risk and uncertainty, which is an important aspect in the assessment of future environmental effects. The existence of risk and uncertainty may also give an argument for adjusting the discount rate. First, we shall briefly review some of the general problems in the valuation of environmental goods.

## 5.1 Valuation of environmental effects

One of the fast growing areas within economic theory over the past few years has been within the development of methods for valuation of environmental goods. CBA is generally concerned with the effects of a project on people's welfare. As the services provided by the environment are important for human welfare, efforts trying to value the environmental effects are clearly justified theoretically.

The environmental effects of a project can be divided into different groups:

consumption (at the average level), as for example UNIDO (1972) and others do. In principle, the choice of numeraire should not affect the result of the CBA. In practice, however, it may do. See Berlage and Renard (1985) for a discussion.

(1) Changes in the environment that affect the production of market goods, as environmental resources are being used in the production process.
(2) Changes in the environment that affect the consumption of environmental goods, like recreational facilities and amenities.
(3) Changes in the environment that affect human well-being directly, like health.[33]

For all these categories a valuation of the environmental effects consists of several steps: First, one should find out the physical changes caused by the project. Second, these changes will have certain ecological consequences. Further, these ecological changes have socio-economic consequences, to which we should assign values. The first two (and partly three) steps are normally left to the natural scientists, but even non-professionals can imagine that already at this stage we may face big troubles. Thus, economists have to rely on the natural scientists' uncertain estimates. "The economic analyst lives rather high on the information food chain" (Randall, 1986, p. 95).

As for the first group of projects, the valuation of the changes in production should be relatively easy. This raises no particular difficulty compared to the other components of a CBA, except that the knowledge on future changes of the environment due to the project will be limited and uncertain. For developing countries, the environmental effects in the first group may prove to be the most important (for example lower agricultural productivity due to soil erosion, deforestation, etc.).

The economic research on evaluation of environmental goods has been concentrated on projects in groups 2 and 3. One major problem related to the measurement of environmental goods, is the public goods attributes of them. This precludes the development of well functioning markets. There are two commonly suggested solutions to this problem: (1) The indirect methods, including hedonic pricing and travel cost approaches, try to reveal the value of environmental goods from observed behaviour in other markets. (2) Direct methods of measurement, including contingent valuation and policy decision making mechanisms, which attempt to reveal preference by asking people. One advantage with the latter methods is that it includes all types of values (see above), whereas the indirect methods only may reveal the use value.[34]

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[33] Changes in health may also indirectly affect the production, as it lowers the quality of the human resource input into the production process.

[34] For those interested, surveys of valuation methods are provided by, among others, Strand (1982),Freeman (1985),Johansson (1987),Nash and Bowers (1988) and Bergstrom (1990).

Even though the methodologies have been developed extensively, and have also been used in policy making, particularly in the United States, Nash and Bowers (1988) conclude their discussion somewhat more pessimistically:

> we are far from a situation in which reliable money valuation can be placed on environmental effects and the normal practice in cost-benefit analysis is either to ignore environmental factors or to use a mixture of quantitative and qualitative descriptions in non-monetary terms. Where irreversible effects of uncertain consequences are involved, it appears that all the literature can do is to warn that a positive benefit/cost ratio does not necessarily mean that the project should go ahead. In these circumstances, cost-benefit analysis should only be used subject to predetermined environmental constraints (p. 118).

Generally, the problems of estimation and quantification seem to be larger for developing countries. This is due to several factors: The data and information available are usually less reliable than in developed countries. Markets are generally less developed or even lacking. This makes it difficult to use market prices as a starting point for social value. For this reason, indirect methods of revealing preferences for environmental goods are less relevant. Methods for direct measurement of the preferences for environmental goods also raise additional problems, e.g. reliable answers require some training in thinking in monetary terms. People may be (even more) unfamiliar and hesitant to put a price on environmental goods. In a survey on valuation of environmental impacts in Indonesia, Barbier (1988) concludes that willingness-to-pay surveys have limited applications. This makes the argument for supplementary methods (chapter 6) stronger when it comes to developing countries.

## 5.2 Risk and uncertainty

As already noted, our knowledge of the value attached to environmental changes is imperfect. Generally, it seems fair to assume that the uncertainty related to environmental impacts are greater than for other impacts. Quantification of this value involves a number of uncertain steps (see above), of which we have limited previous experience. The fact that many of the changes occur far into the future adds new dimensions to the problem. And, as just noted, there are major difficulties in making reliable monetary estimates on ecological changes.

In the process of quantification, one may distinguish between two kinds of uncertainty: (1) Technical uncertainties, because of imperfect knowledge

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about ecological changes, and (2) social uncertainty, because of imperfect knowledge about how society will value these changes.

Economic theory suggests methods to handle risk and uncertainty. The general rule is that, due to risk aversion, a situation with a certain income is preferable to another situation with an uncertain, but the same expected income. In the latter case one can define a *certainty equivalent*, which is defined as the certain income that *a priori* would give a person the same utility as the uncertain one. Because of risk aversion, the certainty equivalent is lower than the expected income in the uncertain case. Individuals act as if they maximise their expected utility, not their expected income.

However, for public projects it is possible to diminish the significance of individual risk-averseness if the risk can be shared. According to the Arrow-Lind theorem,

> when the risks associated with a public investment are publicly borne, the total cost of risk bearing is insignificant, and, therefore, the government should ignore uncertainty in evaluating public investments. Similarly, the choice of rate of discount should in this case be independent of considerations of risk. This result is obtained not because the government is able to pool investments but because the government distributes the risk associated with any investment among a large number of people. It is the risk spreading aspect of the government investment that is essential to this result (Arrow and Lind, 1970, p. 366).

The crucial question is whether the assumptions underlying the theorem hold, i.e. whether the government can share the risk between a large number of individuals *or* whether the project is non-marginal. If this is not the case, the expected utility theory also has implications for the social value of costs and benefits. In a reply to the Arrow-Lind article, Fisher (1973) discusses the validity of the theorem to projects with large environmental costs. He argues that environmental risk may well not be spread in the manner required by the theorem. Some individuals may face a significant risk due to the project. And risk may not easily (costlessly) be transferred from the affected individuals to the larger community. Fisher's conclusion is that in some cases "the environmental effects of an investment project may well be large enough to make the adjustment (of risk) appropriate" (p. 724). Similarly, Anand and Nalebuff (1987) note that project risk is not borne equally across the population. Even though the government in principle could correct these consequences, they suggest that "without strong evidence to the contrary, it is safer to assume that the

government policy will remain unchanged" (p. 200). Thus, the practical relevance of the Arrow-Lind theorem is controversial.

If there is a failure to spread risk, we should take the risk occurring to a group of individuals into account in the analysis. Using expected values in project appraisal may lead to an underestimation of the environmental costs involved, and consequently a level of environmental damage in excess of what is socially optimal. The gap between the expected net benefit and the expected value will depend positively on the proportion of damage cost relative to the income of individuals, the risk averseness of the population, and the variance of the net benefit.[35]

There are two suggestions on how to adjust for risk in CBA: The first is to adjust the costs and benefits by using certainty equivalents, the second is to adjust the discount rate. There is some scepticism against using the discount rate. "Uncertainty about the presence and scale of benefits and costs may be unrelated to time, and certainly appears unlikely to be related in such a way that the scale of risk obeys an exponential function as is implied in the use of a single rate in the discount factor" (Markandya and Pearce, 1988, p. 32). Their suggestion is that risk and uncertainty are better handled by other means, i.e. via adjustments of the costs and benefits using certainty equivalents.

The more recent literature, particularly on the "capital asset pricing model" (CAPM), points out that it is not the risk (variance) of a single project, but rather of the portfolio of an individual's projects, or, for the society, the national income that is of interest. If the risk of a public project can be effectively distributed, a single project should be assessed as to whether it increases or decreases the risk of the total portfolio, i.e. the interesting measure is not so much the variance but the covariance between the project and the portfolio. This is put clearly by Lind (1982, p. 60):

> Many consider any investment that has uncertain return to be risky. They would be right if that investment were the only one in an individual's portfolio, or from the national point of view, if that investment produced a major fraction of the national income. However, from the point of view of an individual, one is not primarily interested in the variability of the return on a single particular investment but, rather, the variability of the return on the total portfolio of assets that produces one's income. From a national point of view, the variability of total income is of interest. One is interested only in the variability of any single component of a portfolio

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[35] The individual's certain equivalent (CE) is approximately determined by this formula: $CE = EV - R\sigma_2/2$, where EV is the expected value of the net benefit, R is the absolute risk aversion and $\sigma_2$ is the variance of the net benefit.

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insofar as it affects the variability of the total portfolio. The recognition of this fact is central to the analysis of risk.

A public project will involve some risk for the nation if it has a positive covariance with the national income. If, on the other hand, the covariance is negative, this particular project has the character of an insurance: The project performs well when the economy performs poorly, and vice versa, and it will stabilize the total level of national income. When the covariance is negative, the discount rate should be lowered.

How are projects with large environmental effects correlated with the returns of the other projects in the economy? We have not seen any systematic discussion of the topic. The covariance will obviously vary among different types of projects, according to the type of environmental impact it represents. One may find arguments for considering environmental preservation as a kind of insurance. If this is the case, we have an argument for adjusting the CBA procedure in a way which may lower the chances for a project with negative impact being accepted. It seems speculative to state that this is a general characteristic, and the question of covariance should be assessed for each individual project.[36]

## 5.3 Uncertainty, irreversibility, option value and quasi-option value

We shall continue the discussion of risk and uncertainty, but now under some additional assumptions on the nature of the problem. First, we assume that the project involves some irreversible transformation of the environment. In defining the meaning of irreversibility, we follow Henry (1974): "A decision is considered irreversible if it significantly reduces for a long time the variety of choices that would be possible in the future" (p. 1006). Technical irreversibility seems relatively rare, but is relevant where for instance development involves extinction of indigenous species. Economic irreversibility seems much more common, i.e. the costs of reversing the development are so high that for practical purposes the project can be considered irreversible.

The second assumption is that there are uncertainties about the future benefits and costs from the project, *and* that we will obtain more knowledge in the future that will reduce this uncertainty. If we are keeping

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[36] The adjustment of the discount rate also depends on how the problem is formulated, see Brown (1983) and Prince (1985).

open the option whether or not to develop for example a wilderness area, we will accumulate more knowledge about the consequences of our choice, and, therefore, be in a position to make better-informed choices later.

Our problem now is to find the optimal development of the wilderness area, given that any development is irreversible, the present uncertainty about future preservation and development benefits, and that more will be learned about these benefits in the future. For simplicity we assume that the agents are risk neutral. But even if we do not assume risk averseness, "something of the "feel" of risk aversion is produced by a restriction on reversibility" (Arrow and Fisher, 1974, p. 318).

The solution of this problem goes back to the work of Henry (1974), Arrow and Fisher (1974) and Fisher and Krutilla (1975). They introduce the term *option value*, which is "the gain from being able to learn about future benefits that would be precluded by development if one does not develop initially — the gain from retaining the option to preserve or develop in the future" (Fisher and Krutilla, 1985, p. 185).

An intuitive interpretation of the main result is given in Arrow and Fisher (1974): "If we are uncertain about the payoff to investment in development, we should err on the side of underinvestment, rather than overinvestment, since development is irreversible. Given an ability to learn from experience, underinvestment can be remedied before the second period, whereas mistaken overinvestment cannot, the consequences persisting in effect for all time" (p. 317).

One should note that the literature is somewhat confusing on the terminology used in this context. The term "option value" goes back to Weisbrod (1964). In the work that followed his article, it was established that the option value could be identified with a risk premium that risk averse people would be willing to pay to avoid the uncertainty associated with future benefits. This interpretation of option value is obviously a different one compared to the one referred to above.

It has become common to use the term *quasi-option value* for the latter (see for example Randall, 1986, and Dixon et al, 1986), even though for instance Fisher and Krutilla (1985) do not follow this terminology, and use option value in both cases, which they, however, clearly distinguish. We shall follow the more recent terminology, and reserve the term *option value* for the risk premium associated with future uncertainty. This assumes risk aversion, and is what we discussed in the previous section. The term *quasi-option value* will be used for the value of delaying the decision and preserving options, given the expected growth in information.

The quasi-option value is closely related to the value of new information, but Fisher and Krutilla (1985) distinguish between the quasi-option value

and the value of information. The quasi-option value is "a conditional value of information, conditional on a particular choice of first period development", i.e. no development in the first period (p. 186).

The quasi-option value will be positive in most cases, as we usually will learn more about both the preservation benefits as well as the development benefits as time goes. In cases where development itself leads to better information for future decisions, the quasi option value may be negative (Miller and Lad, 1984). In the general case it seems fair to assume a positive value because the uncertainty is most likely linked to the preservation benefits (Fisher and Haneman, 1987).

The quasi-option value associated with the preservation alternative will generally make preservation more attractive. The irreversibility of a project is not an argument for using a lower discount rate, but the quasi-option value is a cost that we should attach to the development project — we are losing forever a *possibly* beneficial preservation of the wilderness area. This does not imply that irreversible projects should never be undertaken, but it means that they have an extra cost that should enter the overall analysis of the social profitability of the development project. Using only the expected values (based on present information) will lead to transformations of the environment that are higher than socially optimal because it does not reflect the loss of options it entails.

# 6 Introducing additional or alternative criteria

So far we have discussed two alternative ways of including environmental considerations into CBA. A third and quite different type of adjustments of the traditional CBA is to introduce additional or alternative criteria to the CBA. Some would base this on a fundamental critique of the CBA. Some of the arguments referred to earlier by Sen and Goodin can be interpreted in this way. Others suggest the introduction of new criteria because a correct CBA is very data- and resource demanding, and, in practice, very difficult to undertake (Cooper, 1981). They may agree that, in principle, a CBA that gives the environmental goods a proper measurement and takes account of risk, uncertainty, irreversibility etc. may lead to a socially correct decision. For practical purposes, where the CBA is supposed to operate, one may need other criteria. We shall discuss two suggestions in this direction: Sustainability constraints and Safe Minimum Standards (SMS).

## 6.1 Sustainability constraints and shadow projects

The basic idea of CBA is to transform all cost and benefits, including the environmental ones, to one common unit of measurement, namely the present value in monetary units, and then select the project for implementation if the benefits outweigh the costs. This assumes that all benefits and costs *can* and *should* be measured by the same *numeraire*. The idea behind introducing sustainability constraints and shadow projects is based on the non-quantifiability of certain benefits and costs, either for practical reasons or based on a more fundamental critique. This makes it difficult to reach a conclusion about the social desirability of the project by just comparing *measurable* benefits and costs. One alternative may be, as often suggested, to quantify whatever can be quantified, and describe the rest as best one can qualitatively, and leave it to the normal political decision process to balance net quantifiable gains against qualitative costs.

Another approach may be to introduce a sustainability constraint on the project selection. This is done by requiring that the sum of environmental damage of a package of projects should be non-positive. The idea is summarized by Klaassen and Brotterweg (1976), who introduced the concept of *shadow projects*:

> ... if a project has adverse effects on the natural environment, these disadvantages will have to be compensated by executing shadow projects simultaneously. As a result of this action however, the socio-economic profitability of the basic project will become lower than when there is no need to carry out shadow projects, because the costs of the shadow projects have to be charged to the basic project (p. 40).

A project with negative environmental effects should be followed by compensating (shadow) projects in such a way that the *total* environmental impact is non-negative. The selection among possible (combinations of) shadow projects should, of course, minimize the costs. Pearce et al (1988) and Markandya and Pearce (1988) extend the work of Klaassen and Brotterweg, and suggest that this criterion may be most interesting at the *programme level*, i.e. for a larger number of projects. They also distinguish between two types of sustainability: (1) *Weak sustainability*, where the constraint is that the *present value* of the environmental impacts shall be non-positive; (2) *Strong sustainability*, where the impact shall be non-positive for *each period* of time.

This approach raises two immediate questions. First, we have "the problem of the non-interchangeability of shadow projects" (Klaassen and Brotterweg, 1976, p. 41). Their suggestion is that the shadow project should

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be designed to replace the lost nature such that "the replacement resembles the original as closely as possible" (p. 41). In their view it will be possible in practice to define suitable shadow projects. They go on defining different categories of pollution (noise nuisance, air pollution etc.), and indicate that the shadow projects should compensate for negative effects within every group. This suggestion is close to the one on "non-tradables" in chapter 2. Environmental degradation in one area cannot be compensated for by improvements in another. Markandya and Pearce (1988) stress that the sustainability constraint "is *not* a blind "replace a tree for every tree removed" requirement. ... Rather it is an attempt to accommodate the interests of future generations in a practical way by debiting projects or programmes with the costs of the resource losses" (p. 54).

Some environmental impacts are irreversible in their nature (extinction of species, extraction of non-renewable resources). In these cases compensating projects, *per definition*, cannot be designed. Projects that result in the extinction of endangered species will be hard to justify following this approach. In the case of non-renewable energy sources, the main interest for mankind is the supply of energy, and a compensating project could be designed to increase the availability of other energy sources in the future.

The second question is whether every single (net) depreciation of the environment should be prohibited. There may be cases where the measurable social net gain is large, whereas the negative environmental impact is relatively low, and the cost of a shadow projects very high. Should one in these cases be allowed to trade measurable social gains against natural quality? Klaassen and Botterweg's answer to this question is that "only when it appears that neither avoidance nor replacement is possible, will we be able to satisfy the basic requirement that nature must not be spoiled any further. The question whether the project under consideration is so urgent that it should be carried out in any case should be answered within the framework of the democratic decision-making process" (p. 45).

## 6.2 Safe minimum standards (SMS)

The Safe Minimum Standard (SMS) approach differs from the sustainability constraints in the way that it is more to be considered as an alternative approach to CBA, particularly relevant to questions involving irreversible decisions, e.g. preservation of endangered species. The SMS was developed by Ciriacy-Wantrup (1968), and has later been extended by Bishop (1978). SMS is defined as the minimum level of preservation of species that

ensures survival. Plant and animal species are renewable within limits, but have a threshold or critical zone. Once this zone is reached, further depletion is irreversible. There is a lot of uncertainty associated with irreversible depletion, and the term "safe" indicates that the SMS is a very risk averse approach.

Bishop (1978) develops the SMS approach within the framework of game theory, where the SMS give the same results as the minimax principle, i.e. the strategy that minimizes maximum possible losses.[37] He considers two possible outcomes of nature, one where the species turns out to be very valuable, another where they do not. Society has two options; either developing an area which will lead to extinction of certain species or conservation at a safe minimum level (SMS). The matrix of losses is given below:

### Table 6.1
### Matrix of losses

| Strategies: | Species not valuable | Species valuable | Maximum losses |
|---|---|---|---|
| Development (=extinction) | 0 | y | y |
| Preservation | x | x-y | x |

x = net present value of development project
y = possible value of species

If the species turn out *not* to be of any value for society, then the SMS strategy involves a loss of x, which is the net present value[38] of the development of a wilderness area (hydro power etc.). The species may also turn out to be worth a large amount, symbolized by y. If we choose development, and the species turn out to be valuable, y will be lost. Finally, if the preservation strategy is chosen and the species turn out to be valuable, the net loss will be the cost of non-development (x) minus the

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[37] This should not be confused with the minimax *regret* principle, where the aim is to minimize the maximum "regret", i.e. the difference between the actual pay-off and the pay-off received if the correct strategy had been chosen.

[38] Notice that we do not avoid the discounting issue in this approach.

value of the species (y). The maximum losses for each strategy is given in the right column.

The minimax rule says that we should choose preservation if $y > x$, i.e. if the possible value of preservation is larger than the development benefits. It is also generally assumed that species are of high and increasing value, whereas the costs of preservation are usually low. Thus, in most cases $y$ would be higher than $x$ and the minimax strategy will lead to SMS.

One problem related to the assumptions in game theory and the minimax principle, is that the value of the outcomes are known, whereas the probabilities are unknown. If $y$ is not known, then it is unclear which strategy should be chosen. Moreover, it does not matter whether the probabilities are known or not, they are irrelevant for what we should choose. Suppose we have a situation where the $x$ is slightly less than $y$, but the estimated probability for the outcome that the species becomes valuable is very low. Following blindly the minimax strategy, we should choose the SMS, even though common sense would suggest the opposite. The reason is that the minimax approach only considers the extreme values, and does not utilize other types of information we may have about the problem.

Bishop also notes that there are several problems with this approach. He introduces the *modified minimax principle*: "This decision rule states that the SMS should be adopted unless the social costs of doing so are unacceptably large. How much is "unacceptably large" must necessarily involve more than economic analysis, because endangered species involve issues of intergenerational equity" (p. 10).

In comparing the CBA and the SMS approaches, Randall (1986) notes the following differences between the two:

> The BCA (CBA) approach starts each case with a clean slate and painstakingly builds, from the ground up, a body of evidence about the benefits and costs of preservation. The SMS approach starts with a presumption that the maintenance of the SMS for any species is a positive good. The empirical economic question is "Can we afford it?" or, more technically, "How high are the opportunity costs of satisfying the SMS?" The decision rule is to maintain the SMS unless the opportunity cost of so doing are intolerably high. The burden of proof is assigned to the case against maintaining the SMS.
>
> The SMS approach avoids some of the pitfalls of formal BCA: e.g. the treatment of gross uncertainty as mere risk, the false appearance of precision in benefit estimation, and the problem of discounting. Its weakness is that, rather than providing the answer, it redefines the question. Nevertheless, an appealing argument can be made that "Can we afford it?" with a presumption in favour of the SMS, unless the answer is a resounding NO, it is the proper question (p. 98).

The SMS approach is related to the "environmental rights" approach, as discussed by Sen (1982). His main argument is to define certain environmental liberties or rights, that apply both to members of the present and future generations.

# 7 Summary and conclusions

Two issues have been underlying the discussion in this paper. First, how can environmental considerations be included in CBA, and what is the most appropriate way of doing so? Second, which factors should determine, and what is the "right" level of, the social discount rate?

Regarding the latter question, chapter 4 discussed the rationale behind discounting, both at the individual and social level. Decreasing marginal utility of consumption together with expected economic growth clearly provide an argument for discounting, which, *in principle,* should not be controversial. But it raises questions about future economic growth. The "Limits to Growth" view suggests that we are already approaching absolute environmental constraints on economic activity, which make a continuation of past growth rates impossible. Declining economic growth is clearly an argument for using lower social rate of discounts.

The environmental issue involves questions of intergenerational distribution and equity. The influence of pure time preference on the social rate of discount is (even) more questionable when it comes to decisions with large negative environmental consequences, that may significantly influence the well-being of future generations. If we accept the critique of pure time preference argument, and the "Limits to Growth" arguments, we may arrive at very low discount rates. If, for instance, we assume the elasticity of marginal utility to be one (n=1), and we allow no pure time preference, the social discount rate would equal the growth in consumption. This is, indeed, much lower than the rates presently used.

If we do not trace all the effects into consumption streams, the private return may influence the social discount rate and make it different from the consumption rate of interest, to the extent the displacement effect on private capital formation of public projects is different from the enhancement effect. If the latter effect is higher than the displacement effect, the discount rate used should actually be lower than the consumption rate of interest. In general, it seems difficult to argue that this would characterize projects with large environmental impacts.

Another argument for adjusting the discount rate is the risk associated with future costs and benefits. The most important point is how the return of the project is correlated with other projects in the portfolio, or the

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national income from society's point of view. If the correlation is negative, i.e. the project is a kind of insurance, the discount rate should be lowered for this project. One may find arguments for this being the case for projects with large environmental impacts, but it seems speculative to suggest a negative correlation and a lower rate in general.

Whereas there are good arguments for the view that the presently used rates are too high, this is not to suggest that the fact that projects may have environmental impacts should dictate lower discount rates. It would be putting too heavy a burden on the discount rate and would cause inconsistency in other areas of the analysis. Moreover, as the discussion in chapter 3 showed, this would not be a very precise measure to promote environmental conservation. Indeed, the effect of a generally lowered discount rate would in many relevant cases *not* be increased preservation of the environment.

We have discussed two alternative ways of bringing environmental considerations into an economic assessment. Chapter 5 reviewed some of the more recent extensions of CBA, partly originating as a response to the environmental critique. First, the environmental effects should enter the analysis, and one should take account of how the costs and benefits of a project will develop over time (3.2). Second, the analysis should take explicitly into account some of the characteristics of the environmental effects: They are uncertain and often irreversible. Generally, these extensions will contribute to a project selection and policy that imply less transformations of the natural environment.

The extended CBA would in many situations provide useful insight in the effects of a project, which may be crucial for the outcome of the analysis. However, the extended CBA involves several problems. First, we cannot place reliable money valuation on all environmental effects, so the CBA will not be complete. This is particularly true for impacts that are associated with great risk and irreversibility, which are especially common in developing countries. Second, there are unresolved methodological and conceptual problems with the CBA approach. Finally, environmental issues involve the question of distribution between generations. Welfare economics is generally ill-equipped with tools to deal with the aims of distribution, even though it is very useful in finding means to reach predetermined distributional ends.

For these and other[39] reasons, we would suggest that the CBA approach should be used subject to predetermined sustainability constraints. As

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[39] For a discussion of other reasons why the use of CBA is limited a basic public decision rule, see Randall (1986, p. 92-94).

Randall (1986) observes, this is the way CBA works in other areas as well: "Rather than determinants, benefits and costs become mere considerations in the choice from a set of alternatives which satisfy the basic law of the land" (p. 93). Both the sustainability constraints and to some extent the Safe Minimum Standard (SMS) are examples of such "laws".

The basic question still remains how the environmental or sustainability constraints should be determined and specified. All methods of evaluation involve comparisons of costs and benefits according to some scale of social desirability. CBA makes this very explicit, which makes all the problems of such comparisons more transparent, and, therefore, more open for critique. To some extent the use of sustainability constraints and the modified minimax principle (SMS) are just redefining the questions, rather than providing the answers.

In the end, all methods are used as inputs in a decision process, and the final decisions have to rely on this process, no matter how imperfect it may be. This fact, together with the difficulties discussed, should perhaps make us lower the ambition level when applying CBA to environmental issues. It is partly the same realization that is behind Lind's statement on the purpose of CBA.

> Benefit-cost analysis need not and cannot provide precise answers to policy questions. Rather it is a procedure that can provide a crude but highly useful picture of the relative merits of alternative policies. It can therefore be used to identify those investments that are either very good or very bad. Benefit-cost analysis also organizes the date that bear on policy decisions and does so in a way that educates us about the important elements of a problem and allows us to test the sensitivity of the decisions to changes of those elements (Lind, 1982, p. 24).

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