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

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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

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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

[1] The present report is a slightly expanded version of a paper presented at the 13th Research Meeting for Norwegian Economists in Bergen, 7-8 January 1991. I would like to thank colleagues at CMI for useful comments on draft versions of the paper.

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

[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

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.

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).

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.

[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

[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.

benefits, are increasing over time.[11] Let EC_t be the environmental costs or preservation benefits at time t, and α be the exponential growth rate of these costs: $EC_t = ECe^{\alpha t}$. DB_t is the development benefits at time t, and β 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) $NPV = - 1 + DB/(i+\alpha) - EC/(i-\beta)$

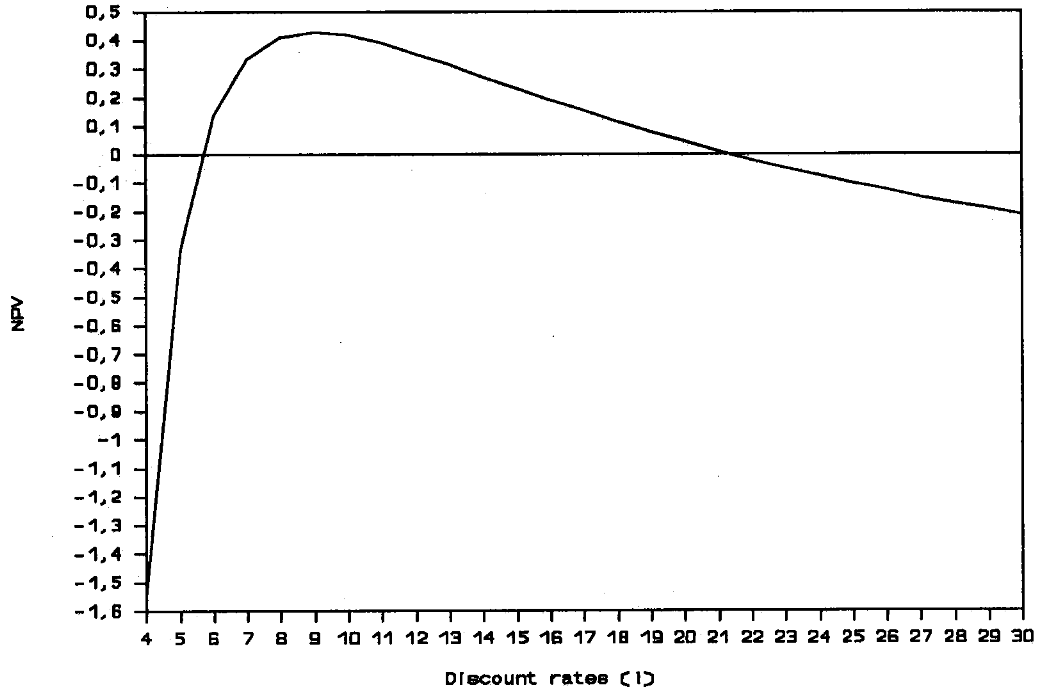
In this case, there may be no unique relationship between the NPV and i. This is illustrated in fig. 3.1. For high discount rates the project will not pass the NPV-criterion because the initial costs are too high compared to the future (highly discounted) benefits. The project may also fail for sufficiently 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.)

[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, α and β. 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



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

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.

3.3Extraction 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 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).

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

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