RECONCILING SUSTAINABILITY AND DISCOUNTING IN COST BENEFIT ANALYSIS: A METHODOLOGICAL PROPOSAL

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Abstract

The incorporation of the intergenerational equity objective has turned the traditional Cost-benefit Analysis (CBA) approach into an obsolete tool in the evaluation of certain types of projects, particularly those presenting an important number of environmental externalities and those whose impacts extend throughout a long period of time. Therefore there is a strong controversy in the scientific community, as to whether or not the traditional social discount rate should be changed on the basis of intergenerational ethical considerations. The different positions are difficult to reconcile since they are based on different environmental ethical standpoints and consequently on different concepts of sustainability.

Based on the assumption that applying a discount rate rewards current consumption and, therefore, that it is only possible to introduce a certain intergenerational equity (at the consensual level of the current generation) in a cost-benefit analysis, in this work we propose an approach to discounting based on a different rationale for tangible and intangible goods. To this end, we propose two different indicators of environmental profitability: one, the Intergenerational Transfer Value (ITV), quantifies in monetary units what the current generation is willing to pass on future generations when an environmental restoration project is carried out. The second indicator, the Critical Environmental Rate (CER), measures the implicit environmental profitability.

These concepts are tested through an empirical case study pertaining the assessment of a Erosion Control Project in the southeast of Spain. The results obtained by applying the proposed discounting methodology reveal traditional profitability indicators that are higher and probably closer to the real values set by the contemporary society (e.g., a Net Present Value of €22 million as compared to the value of €4.8 calculated by traditional approaches). In addiction, the environmental restoration project described entails a quantifiable generational equity level that can be calculated, through the indicators proposed, as €15.8 Million in absolute terms and 4.5% in relative terms. The information provided by the environmental profitability indicators proposed renders more transparency to the quantification of the levels of intergenerational equity applied, thereby facilitating the difficult reconciliation of the CBA technique with the objective of sustainability and, as whole, it is potentially very useful in assisting public decision-making.

Keywords*:* Intergenerational Equity; Sustainability; Social Discount Rate; Environmental Discounting; Cost-Benefit Analysis.

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Reconciling Sustainability and Discounting in Cost Benefit Analysis: a methodological proposal

Introduction

The incorporation of the intergenerational equity objective has turned the traditional Cost-benefit Analysis (CBA) approach into an obsolete tool in the evaluation of certain types of projects, particularly those presenting an important number of environmental externalities and those whose effects extend throughout a long period of time. A series of changes in the CBA are being proposed in the literature, in order to adapt the analytical context to the demand for sustainability, resulting in what is alternatively denominated Extended or Environmental Costs Benefits Analysis (ECBA).

From an analytical point of view, changes in the CBA are taking place in a twofold way. Firstly, by developing new tools for the economic valuation of environmental externalities which traditionally were left out of the analysis. Secondly, through an in-depth revision of the theoretical foundations underlying the traditional approaches to discounting, since the repercussions of decisions that are presently being debated will extend into a distant future (in some cases for centuries), whereas in the classical CBA we deal with few decades at best. Therefore, many authors are stressing the need for a modification in the Social Discount Rate (SDR), by questioning the assumptions that are traditionally taken for granted and applied in its calculation.

The present work firstly shows some reflections on the discounting problem by a revision of the different approaches found in the literature, following by our methodological proposal. Secondly, the practical application of several of these approaches is presented, through the Economic Valuation of an environmental improvement project designed to stop the desertification processes in an area of south eastern Spain: The Watershed Restoration and Control Erosion Project of Lubrín (Almería , Spain).

Discounting in Cost-Benefit Analysis: Background

Discounting has traditionally been a controversial subject. In the seventies, after the great oil crisis of 1973 that took place in the USA, this country and many others faced the need to invest in research for alternative energy sources. It was at that time that the subject of discounting began to arouse great interest among a small group of researchers, since they were dealing with investments whose benefits were not to take place until many years later. So it was that in 1977, Resources for the Future (RFF) made a call for a conference to discuss the adequate discount rate for public investments in energy and other technologies, the seminal ideas of which took form in the well-known text "Discounting for Time and Risk in Energy Policy", published by Robert C. Lind (1982), which was an outstanding contribution, and the basis, during the following fifteen years, of a widespread consensus on the subject of discounting.

However, by the mid-nineties, the apparent consensus on discounting starts to evaporate. In 1995, a report appears on the economic and social consequences of the climatic change and the policies to pursue (IPCC, 1995), in which one chapter is dedicated to subjects related with discounting and intergenerational equity (Arrow et al., 1996). Although there are frequent references to Lind's (1982) book, among other references, a general agreement on discounting is no longer envisioned. In fact, in discussing discounting in the CBA, the existence of two opposing schools[1] is acknowledged, each of which proposes its own methods for selecting a discount rate, and neither of which demonstrates the least willingness to reconcile with the other.

Again, these different approaches to discounting could justify discount rates within a wide range of possibilities.

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[1] Arrow *et al.* (1996) refers to these two schools of thought as prescriptive and descriptive approaches, respectively. For the first ones, the selection of a discount rate is based on what the authors call "ethical principles", or rules related with the device by which the welfare of the different generations is weighed. For the second school, selecting the

Under these circumstances, RFF once again organised an encounter in 1996 and managed to gather many of the best minds in the world (including some of those who had participated in the previous RFF encounter two decades earlier). Climatic change was the example that motivated the discussion, although the conclusions in relation to discounting were meant to be generalised to all decision-making processes of an intergenerational nature.

Next, some of the questions openly put forward on that occasion that are central to the current debate are presented, upon which we will centre our attention in the following section: (1st) Should projects whose effects spread over hundreds of years be dealt with simply as "extended versions" of projects whose main effects do not last more than 30 or 40 years? (2nd)If the answer to the previous question is yes, which is the appropriate discount rate for these cases? (3rd) If projects with significant intergenerational effects are to be evaluated in a different way, how should it be done? Should no discounting be applied?, or should a different discount rate be applied?; (4th) Is the use of the Cost-benefit Analysis appropriate in the decision making process of such questions as climatic change, nuclear residues, etc.?

Assessing Discounting Approaches

Many are the ethical, philosophical and economic arguments in favour of discounting future costs and benefits[2] (Pearce et al., 1989; Broome, 1992; Lind, 1982); however, for some authors, (see, for instance, Pearce and Turner, 1990) the use of a positive social discount rate is incompatible with the intergenerational equity objective. The present debate on discounting environmental benefits and costs is centred on the inconsistency of discounting with the philosophy of sustainability. In other words, discounting is paramount to undervaluing the

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discount rate should be based on the observation of the return rate of the capital invested in a alternative group of goods.

2 Some of the main arguments used to justify the use of a positive social discount rate, specifically of the so called social time preference rate (STPR), are: a) The argument based on the psychological discount caused by the individuals' short-sightedness in looking into the future, whereby any future satisfaction seems less important than future, which means that future generations' preferences count less than our own present ones. As we shall see further down, any discussion on discounting will be closely related to the discussions on the various theoretical conceptions of sustainability.

The conclusions drawn from the previously mentioned RFF 1996 conference, which have been gathered by Portney and Weyant (1999), evidence once again the differences in opinion in relation to discounting in the scientific community and the various ethical positions held. The authors make two clear-cut case distinctions in the subject under debate: short to mid-term projects (40 years and under) and projects of a lengthier time span. One issue all the authors in the book agree on, with one exception, is that of considering it appropriate –even essential– to discount future benefits and costs with some positive discounting. Regarding the short to mid-term time span (40 years and under), most authors believe that failing to discount future benefits and costs would be damaging to future generations, and that the appropriate discount rate in this case is the capital's opportunity cost. Other experts, albeit a minority, are in favour of lower discount rates in this case also. It is in regard to longer time spans than these that the authors most clearly disagree.

Generally speaking, in the environmental discounting[3] literature, where projects carrying an intergenerational impact receive special attention, the different authors tend to favour one of the following options:

(A) To consider unnecessary and/or inappropriate any reduction of the traditional SDR due to intergenerational equity issues.

(B) To favour the need to use discount rates (either constant or variable in time), within the interval (0, SDR).

(C) To question the appropriateness of the Economic Welfare Theory, and consequently of

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that in the present; b) The decreasing social consumption marginal utility argument over time; and c) The uncertainty argument.

3 We use this denomination to refer to discounting associated with projects involving important intergenerational repercussions, usually because they have a long term impact on the environment.

the CBA technique, as the right approach in the decision making process when dealing with climatic change policies, and in general with other problems bearing significant intergenerational consequences.

Particularly, the most representative opinions on applying discounting with the ECBA (Extended Cost-Benefit Analysis), beginning with the most extreme positions of the interval (0, SDR), which are embodied in the following opinions:

a) The only valid discount rate is zero, since it is the only rate that is in accord with a fully intergenerational equity scenario. This is an extreme position, defended by a very small minority, and which more readily represents a critical position against the CBA approach in the decision making process in projects with intergenerational repercussions than a discount rate proposal.

b) The social time preference rate (STPR)[4] is the appropriate and necessary rate to evaluate intertemporal efficiency (among generations). Lesser et al. (1997), among others, sustain that an investment project (or group of these) complies with the rule of intergenerational equity, if present generations can improve their welfare -in terms of consumption- without diminishing

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[4] In practice, the STPR formula works as follows (Pearce and Turner, 1990):

$$STPR = c\,e + p$$

where c = the real per capita consumption rate;

e = the elasticity of the consumption function's marginal utility;

and p = the type of interest of pure time preference.

While component p reflects impatience, parameter e reflects the utility we believe is derived from the additional consumption units and, for the sake of analytical convenience, this relationship is expressed as an elasticity, that is, the change in marginal utility that arises arise from a change in marginal consumption. The component ce, hence, represents the idea that, since it is likely that future societies will be richer, we allot a smaller weight to their earnings, and should therefore discount those future earnings. This is what is called the decreasing consumption marginal utility principle. It is a straightforward principle, that, translated, amounts to the following: the more we have of something, the lower the increase in satisfaction we derive from the addition of another unit of the same thing. Generally speaking, the better off we find ourselves, the lower the increase in satisfaction we get out of improving a little more. Thus, according to this logic, if in fifty years, judging by the historical evidence in this respect, people will be better off in terms of welfare, the damage that they will be caused when depriving them of something will be smaller than the damage that will be caused to those that are alive today, who are worse off, and have more urgent needs to meet.

the welfare of future generations. Conversely, we will be unjust with regard to future generations if we leave them worse off than we could. At the foundation of this line of reasoning lies the idea that, in practice, a positive discount rate is associated with capital accumulation and to technological change, which will allow future generations to be better off[5].

c) Reductions in discount rates in favour of the environment are unnecessary if we operate with a strict no-decrease restriction on the endowment of natural capital. This is the position held by authors (see Pearce and Turner 1990; Pearce, Barbier and Markandya, 1990; Barbier *al.* 1990) who believe that adjusting the STPR after the environmental externalities have been included is wrong as it involves a double accountancy. Acknowledging the shortcomings of the weak sustainability concept, Pearce and Turner (1990) try to make the strong or strict sustainability concept compatible with the decision evaluating process, by imposing the constraint that, no matter what the benefits and costs associated with the decision may be, the environmental capital stock must remain constant. For example, in order to back a certain project, the benefits should be greater than the costs, but there must also be a proviso requiring any environmental damage caused by this project to be compensated through restoration and rehabilitation.

Since this provision would be very strict and hardly operative, these authors recommend considering a whole series of decisions on development projects and imposing on them the strong sustainability condition in the following way: the sum total of the environmental damage caused by an entire sequence of projects can be counteracted by separate projects within the set of "decisions to be made". These corrective, or "shadow", projects would be an attempt to compensate for the reduction in natural capital stock through the creation and deliberate increase of this stock. Shadow projects would not be required to pass any kind of test relating

[5] In our opinion, this reasoning could only be true if a perfect substitution capability existed between natural capital and other types of capital, which no doubt is very debatable, especially when we consider that decisions affecting the environment are often associated with irreversible changes.

the costs with the benefits, since their justification would lie in their compliance with the requirement of this type of sustainability[6].

In the description of the three positions outlined so far, it is clear that beneath the positions defended by the different authors lie different concepts sustainability. Table 1 shows, by way of a summary, a correspondence among the various positions towards environmental discounting and the underlying sustainability concepts.

Table 1. The concepts of sustainability underlying some of the positions towards discounting	
Position towards environmental discounting	Underlying Concept of sustainability
a) The only discount rate compatible with a scenario of full intergenerational equity is zero and/or other methodologies must be found for the decision making process.	*Ecological sustainability*, also termed "thermodynamic"; based on ecological sustainability indicators, which sets it apart from the two following ones that are based on economic indicators. It is defined as the Ecological Economy approach.
b) The social time preference rate (STPR) is the appropriate and necessary rate to evaluate intertemporal efficiency (among generations).	Sustainability in the "neoclassical" sense, which assumes total capital constancy, including both natural assets and manmade capital. It is also called *weak sustainability*.
c) Reductions in discount rates in favour of the environment are unnecessary when we operate with a strict no-decrease restriction of the endowment of natural capital.	*Strong sustainability*, which demands natural capital stock constancy over time. This type of sustainability is the one defined by the so-called "London School of Economics."

Given that the extended CBA adds monetary units that can arise both from the natural and man-made capital, in decision making processes this tool is often considered compatible only, at best, with a philosophy of weak sustainability (see for instance Martínez Alier , 1999 and Martínez Alier and Roca Jusmet, 2000). This leads us to acknowledge a fundamental problem – whose importance is, of course, debatable- of cost-benefit analysis when it incorporates the economic valuation of environmental externalities. However, this does not necessarily mean that there is no place for the CBA tool in a decision making process that could include the

[6] The philosophy of strong sustainability underlying this position is not free from objections and criticism either. Rather than in its theoretical conceptualisation, the problem lies in the difficulty in making it operational.

sustainability objective. We believe that the use of CBA in an intergenerational context can make sense if the degree of intergenerational equity is explicitly accounted for in the analysis. This is the central idea underlying this work, and that is what the environmental profitability indicators designed aim at materialising.

d) After outlining and briefly discussing the extreme positions of the interval (0, SDR), a group of opinions that share a common preference for coherence and which defend the need to use discount rates located within this interval, which can be constant or variable in time (hyperbolic function), are presented next. Within this group three main orientations can be considered, not clearly separable in practice.

d.1) Constant reduced discount rates

Many authors defend the reduction in discount rates due to environmental considerations, established in a conventional manner, as a type of rational adjustment in the conventional discount rates. Thus, due to the difficulty of finding a convincing discount rate to apply in practice, they request a pronouncement from the public administrations regarding the rate that should be applied in public capital endowment projects (Horta, 1998; European Commission, 1998; Rabl, 1996).

d.2) Obtaining the discount rate empirically

One can find in the literature some attempts to obtain in an empirical way the discount rate that would be necessary to apply towards the welfare of future generations**.** Several routes are followed. One of them consists in discovering the present generation's opinion in this respect. In other words: to discover what value is allocated to a change that will take place in the future (Luckert and Admowicz 1993; Cropper *et al.* 1992; Benzion *et al.* 1989 and Poper and Perry 1989).

d.3) Variable in time discount rates

Azar and Sterner (1996), in a study in which discounting in relation to the Earth's over-warming effect is analysed, believe the discount rates used in the economic models of climatic change should be lower than those traditionally used, and that constant discount rates in time are unreasonable; instead, the discount rate should decrease over time. Other authors who mention the possibility of a non-constant discount rate in time are Arrow, Weitzman and Kopp, and Portney; and this possibility constitutes the central idea in Cropper and Laibson's (in Portney and Weyant, 1999) presentation.

This idea of a variable discount rate is gaining support from a growing number of studies in which individual discount rates can be inferred or observed in the present market behaviour (Hausman, 1979) or in response to hypothetical issues connected to people's attitude toward risk (Horowitz, 1991), savings behaviours (Thaler, 1981), or found in life saving government agency programs (Cropper et *al*., 1994). Henderson and Bateman (1995), following the works of Cropper *et al.* (1992), obtain for the discounting on human lives a form of the hyperbolic discount curve that is different from the curve generated by the classical discounting (exponential), and which they consider more realistic for projects with intergenerational implications.

In the same vein, more and more authors defend applying variable discount rates in time following a decreasing hyperbolic function, with values between zero and the STPR (Sterner, 1994; Henderson and Bateman, 1995; Azqueta, 1996; among others).

A proposal on environmental discounting

The central idea that we propose for intergenerational discounting is to defend the rationality of ***using different discount rates for intangible effects (e.g. environmental) than we use for tangible ones, used simultaneously in the same CBA exercise***. We have not found in the literature specific theoretical developments postulating this approach, nor practical applications, although we did find some brief comments (see European Commission, 1997) and empirical works that aim in this direction. This idea –discussed previously in Almansa and Calatrava (2000, 2002)- would be based on the following reasonings:

1. ***Since environmental goods are not market goods, individuals act with different ways of thinking when they are dealing with "merchandise" that when they deal with "environmental goods"***.

If we consider that the most coherent Social Discount Rate that should be applied to market effects is the Social Time Preference Rate (***STPR= ce + p***)[7], it is only logical to suppose that the interest rate of pure time preference (p) will be smaller in the case of environmental goods, whether it be out of an ethical "imposition" of intergenerational equity, or simply because of empirical evidence that certain studies seem to reveal in this direction.

In addition, governments carry out environmental enhancement projects that often would not pass the decision making criteria of the classical CBA, and whose benefits will be enjoyed by future generations, from which one can infer a very low environmental discount rate, as the United Kingdom does, by applying a lower than usual discount rate in the case of forestry projects, as a "grant for future generations."

Kopp and Portney (1999) believe that there are no reasons for taking for granted that individuals will be willing to exchange money and the environment with the same logic. This idea is implicit in Lumeley (1997) when he comments on empirical works that link individual discount rates with practices carried out in land preservation projects, in which there does not seem to be any clear relationship between one and the other. Gintis (2000) arrives at the same conclusion. In a study already mentioned above, Luckert and Admowicz (1993), deduce different behaviours when dealing with discounting of forests and of holdings securities. Recently, Taylor et al. (2003) obtained implicit discount rates that were different for forest benefits of distinct nature, namely timber and recreation.

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[7] See footnote 4

2. ***It seems logical to think that the hypothesis of the marginal utility consumption decline will not be met in the case of environmental goods[8].***

If the environmental benefits or costs take place over a long period of time, the term *ce* of the STPR formula[6] may decrease for this type of goods, since the hypothesis of the marginal utility consumption decline is not fulfilled. Thus, if in two hundred years, for example, people are going to be worse off in terms of "environmental welfare", the damage caused to them by depriving them of an environmental good (a natural space for recreational purposes, for example) will not be slighter in any way than the damage it would cause to those that live today, as is usually affirmed.

The idea that per capita consumption decreases instead of increasing with the passage of time has been held by many authors (based on the idea that future growth and natural capital stock go hand in hand), and it is one of the central themes in criticising discounting on the part of many ecological economists, who are accused by others of creating pessimistic scenarios (see for example Azar and Sterner,1996 and Dasgupta et *al.*,1999).

This line of reasoning, that reinforces the use of different discount rates for environmental and non-environmental effects, is closely associated with the logic of the well-known Krutilla and Fisher model, which attempts to introduce the problem of irreversibility in the cost-benefit analysis context, where some considerations of great interest appear in relation to discount rate in these cases (Krutilla and Fisher, 1975; Fisher and Krutilla, 1985; Porter 1982).

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8 Considering the current rates of depletion of non-renewable resources and of the global climate changes, among other factors, its in reasonable to assume that the average wealth of future generations will be lower that that of the current one (Martínez Alier , 1999 and Martínez Alier and Roca Jusmet, 2000). Of course, this assumption on the future based on a "precaution principle", is an open, arguable issue.

However, the debate around this hypothesis should not be confused with the "insensitivity" found for the various different amounts offered for the very same environmental good in Contingent Valuation (CV) studies (*embedding effects*, e.g. Desvousges *et al*, 1993). In fact, this is precisely one of the major unresolved methodological hurdles in the CV method, as acknowledged by the NOAA (Arrow *et al*., 1993). Kahneman y Knetsch (1992) explain these effects by

This proposal on discounting could be represented in the following way (equation 1):

$$NPV = \sum_{t=0}^{t=n} \left(\frac{F_t}{(1+STPR)^t} \right) + \sum_{t=0}^{t=\infty} \left(\frac{N_0}{(1+EDR)^t} \right) \qquad (1)$$

where F_t represents the annual net financial cost or benefit (in general, the shadow price of the tangible effects), and N_0 the annual environmental cost or benefit[9] (in general, the shadow price of the intangible effects). The discount rate varies, using the appropriate *STPR* (Social Time Preference Rate) value for the financial effects, and a lower discount rate, an Environmental Discount Rate *(EDR)*, for the environmental effects.

<u>But what specific value(s) would the EDR take on?</u>. We can hardly give only one answer to this general question, but we have the following suggestions:

(i) This environmental rate should not be the same one for all types of projects, nor resources, and will depend on the time span considered. Weitzman (1998) interviewed more than 1,700 economists, and a group of 15 "experts" on their intergenerational discounting preferences, from which were derived different discount rates for certain time spans that we find quite reasonable, although we obviously need to work harder in defining these discount rates. Thus, Weitzman (1999) proposes the following discount rates for different time spans: 3-4% (the usual social discount rate) for time spans of around 25 years; 2% when they are of 25-75 years; 1% when they are of 75-300 years; and 0% for more than 300 years.

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the tendency of interviewees to express a willingness greater than they would otherwise do that derives from their moral satisfaction of contributing to the provision of a public good.

[9] From a theoretical standpoint, it would be logical to formulate Nt instead of N_0, but the difficulty in proposing future values of Nt; that is, estimates of the stock of natural capital, and, which is even more troublesome, in assessing the preferences or usefulness that its "consumption" will provide to future generations, leads, in practice, to the use of a value for future environmental fluxes assessed by the current generation, albeit adjusting the denominator through the environmental discount rate.

(ii) The idea of the hyperbolic discount factor seems to us reasonable in projects with very long time spans (several centuries). However, a lot of work remains to be done in defining the specific parameter values for this type of functions.

And so, to summarise, what we seek in discounting, can, in a very general way, be summed up in Table 2.

Table 2. A general proposal of different STPR (Social Time Preference Rate) and EDR (Envionmental Discounting Rate) depending on the time span of the project

Time span	*Discounting*
< 25 years Time span that only affects the present generation	STPR = ce + p**(*)** and EDR = ce +p^1 p^1<p 3%<STPR<5% and 2%<EDR<3% • Reasonable use of the ECBA (Extended Cost Benefit Analysis) approach
25-100 years Reasonably short time span that affects our children, grandsons and great-grandchildren	STPR = ce + p and EDR = ce^2 +p^2 p^2<p and ce^2<ce 3%<STPR<5% and 1%<EDR<2% • Use of ECBA together with other tools and/or decision-making criteria • Prior strict and/or ecological sustainability restriction
100-200 years Time span that affects the less immediate generations, with a reasonable degree of uncertainty	STPR = ce + p and EDR = ce^3 +p^3 p^3<p and ce^3<ce 3%<STPR<5% and 0%<EDR<1% • Introduce hyperbolic discount rates in the sensitivity analysis • Use of ECBA together with other tools and/or decision-making criteria. • Prior strict and/or ecological sustainability restriction.
More than 200 years	• Use of hyperbolic discount rates • Adequate ECBA approach?

(*) See footnote 4

Environmental Profitability Indicators

As a complement to the previous proposal, and in keeping with the established approach, two concepts have been tested (Almansa, 2005) that we consider of interest in the CBA application:

a) <u>Intergenerational Transfer Value (ITV)</u>

The Intergenerational Transfer Value (ITV) is a criterion for the quantification of environmental profitability in absolute terms. It is defined as the difference between the Net Present Value (NPV) that is obtained using the general STPR for public investments, the NPV (STPR%), and the NPV in which an intergenerational equity adjustment has been carried out on the discount rate applied to the environmental effects, the NPV (STPR%, EDR%). See equation 2 where N represents the environmental flow, calculated in year 0.

$$
\begin{aligned}
ITV &= VPN\ (STPR,\ EDR)\text{-}VPN\ (STPR) = \\
&\left(\sum_{t=0}^{t=\infty}\left(\frac{F_t}{(1+STPR)^t}\right)+\sum_{t=0}^{t=\infty}\left(\frac{N_0}{(1+EDR)^t}\right)\right)- \\
&\left(\sum_{t=0}^{t=\infty}\left(\frac{F_t}{(1+STPR)^t}\right)+\sum_{t=0}^{t=\infty}\left(\frac{N_0}{(1+STPR)^t}\right)\right)= \\
&\sum_{t=0}^{t=\infty}\left(\frac{N_0}{(1+EDR)^t}\right)-\sum_{t=0}^{t=\infty}\left(\frac{N_0}{(1+STPR)^t}\right)
\end{aligned}
\qquad (2)
$$

It represents in some way, what the present generation passes on to future generations, and it can be regarded as the inclusion of the sustainability objective in the analysis.

Logically, this value will be higher or equal to zero, and when alternative projects of environmental restoration are compared, a higher value of ITV will indicate a higher environmental profitability of the project[10].

b) Critical Environmental Rate (CER)

The Critical Environmental Rate (CER) is defined as the discount rate that, applied to the environmental effects, after the market effects have been discounted from the usual STPR, make the Net Present Value (VPN) be equal to zero.

The CER is obtained from the following equation, where STPR is a previously chosen value, F the annual financial flow and N the environmental flow in year 0 (see equation 3).

$$\sum_{t=0}^{t=n}\left(\frac{F_t}{(1+STPR)^t}\right)+\sum_{t=0}^{t=\infty}\left(\frac{N_0}{(1+CER)^t}\right)=0 \qquad (3)$$

It is, therefore, a criterion related to the environmental profitability of a project in relative terms. In order to interpret it, it is necessary to compare it to the Social Environmental Discount Rate (SEDR); that is, the environmental discount rate that adequately represents the level of intergenerational equity a society is willing to assume. From this methodological perspective, it must be fulfilled that:

$$CER\ (STPR\ \%) > SEDR$$

For example, if SEDR and STPR are 1% and 3 % respectively, projects with CER (3 %) > 1% will be profitable from an environmental point of view (with adjustments for sustainability), although they need not to be so from a financial point of view (with no adjustments for sustainability), if also CER (3 %) < 3%.

[10] In the case of projects in which the environmental effects have a negative sign, that is, projects that have a positive financial flux but a negative environmental flux (e.g, the activation of a nuclear power plant where the negative effect would be given by the effect of radioactive residues), the ITV would be negative as a result of a sustainability adjustment that assigns more weight to the environmental damage for the future generations.

Another way of viewing this criterion is to considerer it as an indicator of "environmental profitability that the financial cost produces" [11].

The limits and interpretation of the values of the two environmental profitability criteria proposed is outlined in appendix 1.

Applying different discounting approaches to the WREC Project of Almería (Spain)

The Watershed Restoration and Erosion Control Project of Lubrín (De Simón *et al*., 1990; De Simón, 1993) covers an area of 8.830 Has. that experiences "accelerated" or "extremely accelerated" erosion processes in 82% of its territory. There are climatic and orographic conditions which contribute to the desertification processes, but without doubt those with the greatest impact are those of human factors, both historical (deforestation processes), and the current use of land determined by the abandonment of farming land, in a typical marginal mountain agricultural zone.

The main corrective actions considered in the project are: a) maintaining farmland but improving the step slopes, b) reforesting 85% of the areas currently covered with degraded mediterranean scrub with indigenous species, regenerating the remaining 15% of Mediterranean scrub, and c) to construct specific infrastructure of hydraulic correction.

The project covers a time span of 100 years. Logically, this period was chosen by convention for the analysis, due to the long maturing period of the species. The budget of material execution amounts to 9,258,396 €, and the realisation of corrective measures (investment) is planned in the first six years. Whereby it is deduced that, whilst the financial costs are supported by the present generation, the environmental rewards are seen within the medium to long term, thus affecting future generations.

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[11] As in the previous criterion, for projects with a positive financial flux but a negative environmental flux, we would rank the projects also aiming at selecting those with higher CER. In this case, a higher CER would be interpreted as a lesser environmental damage associated to the financial benefit.

In order to apply the ECBA to the case study (Almansa, 2005), the following stages were carried out:

(1) **Identification of the positive and negative effects** (economic, social and environmental) of the project (more details in table 2). Given the multidisciplinary nature of the project, numerous experts in various relevant areas of the study were consulted. Defining, among many other matters, various future scenarios of the zone both in the hypothetical case of the project start-up and that of its non-implementation. In parallel, members of the population concerned were consulted through qualitative techniques (mainly semi-structured interviews), endeavouring to ensure representation of the different groups affected by the project.

(2) Identification and application, from among the different available methods of **environmental benefits valuation**, the most suitable one for the case study, which led us to choose, for various reasons, a Contingent Valuation (CV) exercise on the project as a whole. The CV exercise was carried out in summer 2000, through personal surveys done by suitably qualified and advised interviewers. The random sample (stratified by socio-economic profiles) size was a total of 334 individuals. The information package showed, between other information, the current situation of the zone affected by the project and the future situation of the zone in future scenarios within 50 and 100 years, if no corrective measures were taken of an environmental nature (Figure 1). A net annual benefit was finally obtained of around 506,797 €/year.

Table 2. Identification of Cost and Benefits derived from the WREC Project of Almería (Spain)	
BENEFITS	*COSTS*
Benefits derived from the increase in DIRECT USE VALUE: • Increase in agricultural productivity. • Benefits from wood production. • Indirect multiplying effect: Rural Tourism and others. • Direct multiplying effect: Job generation due to construction work, etc.	Costs derived from the effects caused by a decrease in DIRECT USE VALUE: Decrease in available surface for pastures as a result of implementing of permanent plant coverage.
Benefits derived from the increase in the INDIRECT USE VALUE OF PRODUCTION: • Increase in aesthetic and recreational use. • Increase in use for hunting. • Benefits derived from infrastructures needed to carry out construction work: improvements in forest trails, new roads and trails, firebreaks, etc.	Costs derived from the effects caused by a decrease in the INDIRECT USE VALUE OF PRODUCTION: Negative impact on the landscape due to: a) Construction work; b) new infrastructures; and, c) required hydraulic infrastructures.
Benefits derived from the increase (or that prevent the decrease) in the INDIRECT USE VALUE OF CONSERVATION: • Benefits derived from the maintenance and improvement of ecological values. – Benefits considered as priorities in a hydrologic-forestry restoration project: a) flood control, b) Refilling of aquifers, and c) Soil protection. – Other benefits derived from the maintenance and improvement of ecological values: a) CO_2 fixation; b) Regulation of climate conditions; c) Life-supporting functions; among others. • Maintenance of socio-cultural, scientific, educational, spiritual and historic values.	COST OF CONSTRUCTION WORK AND MAINTENANCE.
Benefits derived from the increase in FUTURE USE VALUE and EXISTENCE VALUE	

PRESENT (year 0)

WITHOUT PROJECT (year 50)

WITHOUT PROJECT (year 100)

PRESENT (year 0)

WITH PROJECT (year 50)

WITH PROJECT (year 100)

Figure 1.
Photographs of four future scenarios of the WREC Project of Lubrín

(3) Calculation of the project's Economic Profitability Indicators:

The Internal Return Rate (IRR) was 5.23%, which means the project surpasses the positive net present value (NPV>0) in all cases studied, since the highest discount rate used in the sensitivity analysis was 5%. The different discount approaches applied were the following:

a) Discount rates recommended by the European Union (5 %), and by several experts in the specific Spanish case (3 %), following a traditional approach (see table 3.a).

b) Lower discount rates than the traditional ones, following the well-founded lines of reasoning of various authors, in the 1-3 % range (see table 3.b).

c) Different discount rates for tangible and intangible effects, following the methodological approach suggested (see table 3.c).

Table 3.a. Net Present Value of the Lubrín HFR project with the classical discounting approach

Discount rate	*Net financial cost*	*Net environmental benefit*	*Net present value*
5 %	-10,258,177 €	10,561,814 €	**303,637 €**
3 %	-11,704,032 €	16,494,672 €	**4,790,643 €**

Table 3.b. Net Present Value of Lubrín HFR project with discounting approach "STPR downward adjustment"

Discount rate	*Net financial cost*	*Net environmental benefit*	*Net present value*
3 %	-11,704,032 €	16,494,672 €	**4,790,643 €**
1 %	-18,474,235 €	32,262,304 €	**13,788,068 €**

Table 3.c. Net Present Value of the Lubrín HFR project with the discounting approach "using different discount rates for tangible and intangible effects"

Discount rate	*Net financial cost*	*Net environmental benefit*	*Net present value*
C(5 %) and **B(3 %)**	-10,258,177 €	16,494,672 €	**6,236,495 €**
C(3 %) and **B(1 %)**	-11,704,032 €	32,262,304 €	**20,558,271 €**
C(5 %) and **B(1 %)**	-10,258,177 €	32,262,304 €	**22,004,126 €**

As the respective tables show, the project's NPV variability is very large, depending on which discounting approach is used, reaching its lowest value of 303,637 € in the case of the classical discounting, using a SDR of 5%; and its highest value of 22,004,126 € when downward adjustments of the discount rate were made for the particular case of the net environmental benefits (SDR of 5% and EDR of 1%), following our suggested approach.

But, what about if we consider a time horizon span of the project around centuries? What will be the yearly present value at, for example, 200 or 500 years? In following tables we calculate to compare the present value of intangible effects (environmental benefit) within 50, 100, 200 and 500 years using exponential (see table 4.1 and figure 2) and hyperbolic discount factor (see table 4.2 and figure 3).

Table 4.1 Present Value of WREC Project Benefit (500,787 € in year 0) using exponential discount factor (classical approach of discounting)

Discount rate	50 years	100 years	200 years	500 years
5 %	44,220 €	4 €	0 €	0 €
3 %	115,604 €	27,161 €	1 €	0 €
1 %	308,153 €	189,230 €	69,272 €	4 €

Table 4.2 Present Value of WREC Project Benefit (500,787 € in year 0) using hiperbolic discount factor (*)

Discount rate	50 years	100 years	200 years	500 years
FD_h, (a = b = 2r) r = 5 %	84,466 €	46,072 €	24,133 €	9,936 €
FD_h, (a = b = 2r) r = 3 %	126,699 €	72,400 €	38,864 €	16,348 €
FD_h, (a = b = 2r) r = 1 %	253,399 €	168,932 €	101,359 €	46,012 €

(*)The discount factors have been calculated according to the following formula, where parameters *a* and *b* have been defined as a = b = 2r, after Poulos and Whittington, 2000.

$$FDh = \frac{1}{(1+at)^{b/a}}; \quad a,b > 0$$

It can be observed that the maximum values for years 50 and 100 correspond to exponential discount factors (EDF) with SDR=1%, while in the case of years 200 and 500 the maximum values are represented by hyperbolic discount factors (HDF) with parameters a=b=2r, for r=SDR=1%. This agrees with our conclusions, presented in the theoretical section, regarding the advisability of using hyperbolic discount factors in the case of very long-term scenarios. Importantly, the use of an EDF reveals also that the population at the present day attaches little value to Lubrín becoming an environmental restored area instead of a desert.

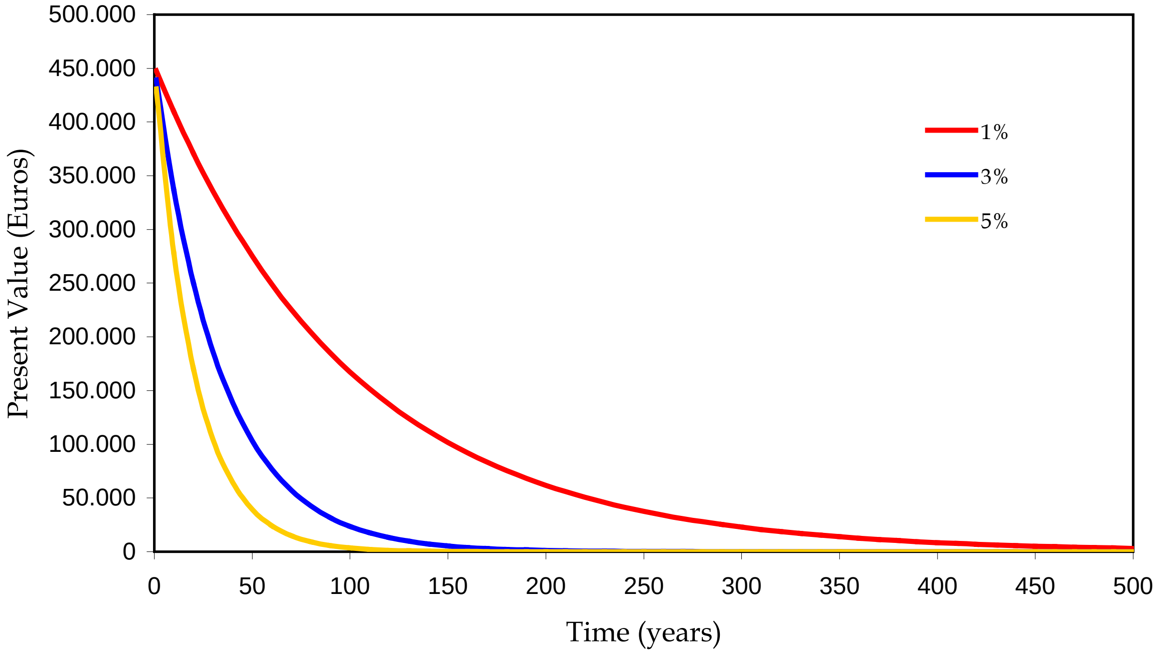

Figure 2. Present Value of Project Environmental Benefits (time span of 500 years) using exponential discount factor (classic approach)

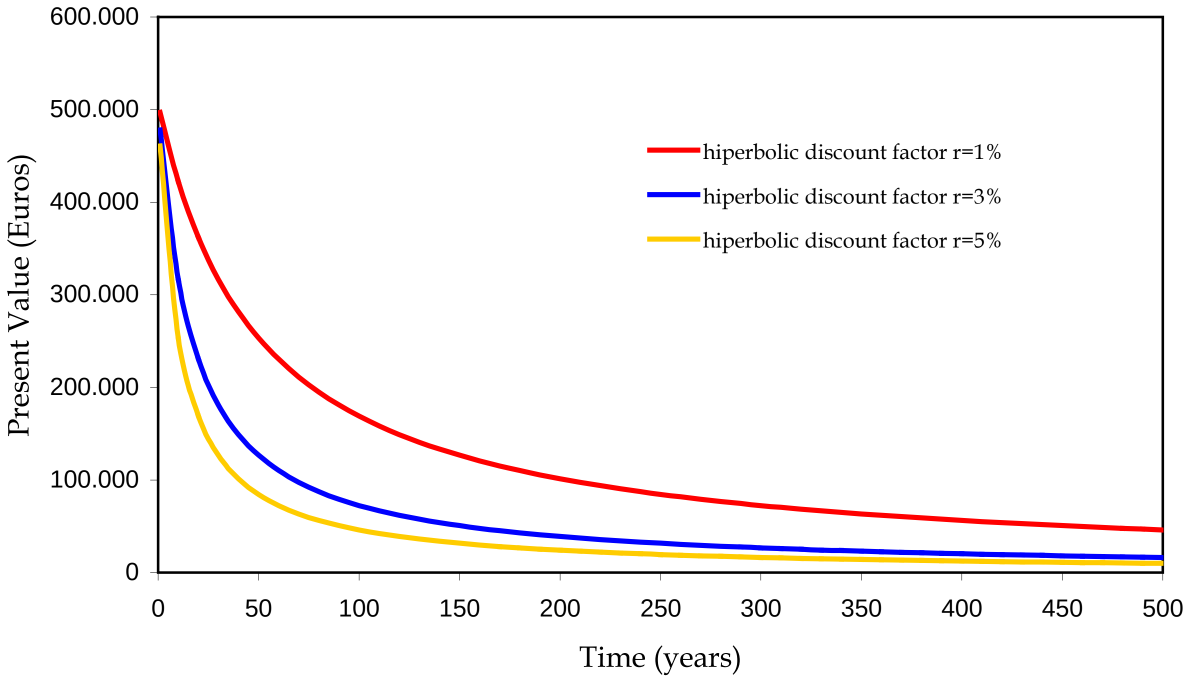

Figure 3. Present Value of Project Environmental Benefits (time span of 500 years) using hyperbolic discount factor (see table 4.2)

(4) Calculation of the project's Environmental Profitability Indicators:

The Intergenerational Transfer Value, **ITV (3%, 1%)**, is represented by the difference between the NPV (3%), and the NPV (3%, 1%) in which an intergenerational equity adjustment was made on the discount rate used on account of the environmental effects, which in this case study reaches the value of **15,768 million €** (obtained from equation 4).

ITV (3%, 1%) = VAN (3 %, 1%) - VAN (3%) = 20,558,271 € - 4,790,643 € = 15,767,628 € (4)

Additionally, the value of the Critical Environmental Rate (CER) for STPR = 3%, that is, the **CER (3%)** is obtained by resolving the equation 5:

$$NPV(3\%, EDR = ?) = -11{,}704{,}032 + \sum_{t=0}^{t=\infty} \left(\frac{N_0}{(1+CER)^t} \right) = 0 \qquad (5)$$

Arriving at a CER (3%) value of **4.47 %**, which indicates that if, for example, we establish the environmental discount rate that adequately represents the intergenerational equity level we are willing to assume at 1% or 2 % (for this time span, see for instance the proposals by Weitzman (1998 and 1999) [12] and Almansa (2005)), under this methodological logic the project in question would be profitable from an environmental point of view, while also being above the minimum social profitability value represented by the STPR of 3%.

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[12] Weitzman (1998) interviewed more than 1,700 economists, and a group of 15 "experts" on their intergenerational discount preferences, from which were derived different discount rates for certain time spans that we find quite reasonable, although we obviously need to work harder in defining these discount rates. Thus, Weitzman (1999) proposes the following discount rates for different time spans: 3-4% (the usual social discount rate) for time spans of around 25 years; 2% when they are of 25-75 years; 1% when they are of 75-300 years; and 0% for more than 300 years.

Conclusions

Extending CBA analysis to include intangible (non-market) effects, such as the environmental impact, even those spanning very long periods of time, demands a reassessment of the classical arguments on discounting.

Attempts to justify scenarios of full intergenerational equity in the CBA analysis are hard to take on. We must not forget that this tool is based on the Economic Theory of Welfare, which is based in turn on the Theory of Utility, an admittedly anthropocentric approach.

That is to say, the CBA relects, at best, our own intergenerational ethics, expressing what our present generation is willing to pass on to future generations, but we will most likely never find a way to reasonably include future generations' preferences in our formulations.

The controversy about whether or not to adjust the social discount rate for intergenerational equity reasons, conceal different concepts of sustainability. This is the reason why the various positions are almost impossible to reconcile; the bottom line is that the debate does not deal with technical but with ethical issues.

If, in spite of the previous limitations, one still is to use CBA, the inclusion of a certain level of intergenerational equity, as one of the valuation criteria of a project, entails the need to use lower discount rates. Furthermore, the difference of logics we adopt in managing goods with and without a market must be mirrored through the use of a different discounting logics.

For all these reasons, we propose the use of the common social discount rate for market goods and a lower discount rate (environmental discount rate) for non-market good, to be used simultaneously in the same CBA exercise.

By quantifying and stating clearly the degree of intergenerational equity implicit in an environmental project, the indicators of environmental profitability proposed elicits more transparency, helps in reconciling the CBA technique with the objective of sustainability and may be useful in public decision-making.

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Appendix 1 Interpretation of the values obtained from environmental profitability criteria

Case A. Environmental Restoration Project; that is, a project in which the positive environmental impact extends throughout a long period of time. It is that with a $F<0$ and $N>0$, i.e., a negative financial flux (cost) and positive environmental flux (environmental benefit).

A. 1) ITV= 0 without sustainability adjustment

A. 2) ITV>0 with sustainability adjustment. A higher ITV entails a larger transference of environmental resources to future generations

A. 3) CER= SDR for a NPV=0, so that CER has to be larger than SDR for the project to be accepted from a financial viewpoint (no sustainability adjustment).

A. 4) When SCER < CER < SDR the project is not financially rewarding but environmentally profitable, being the SCER the Environmental Discount Rate that represents the level of intergenerational equity for the society under consideration.

A. 5) A larger CER entails higher environmental profitability provided by the financial cost.

Case B. Project with negative environmental impact; that is, negative environmental impact that extends throughout a long period of time. It is a project that has a $F>0$ and $N<0$; that is, a positive financial flux (benefit) and a negative environmental flux (environmental cost).

B. 1) ITV= 0 without sustainability adjustment

B. 2) ITV<0 with sustainability adjustment. A higher absolute ITV entails a heavier weight to the environmental impact for future generations, that is, larger intergenerational equity.

B. 3) CER= SDR for a NPV=0, so that CER has to be larger than SDR for the project to be accepted from a financial viewpoint (no sustainability adjustment).

B. 4) When SCER < CER < SDR the project is not financially rewarding but environmentally profitable, being the SCER the Environmental Discount Rate that represents the level of intergenerational equity for the society under consideration.

B. 5) A larger CER entails lesser environmental damage associated to financial benefit.

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