

Social Discount Rate: A Revision

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Abstract This paper is focused in the problem of choosing a social discount rate (SDR) for public investment projects. The standard use of the cost-benefit analysis based on the exponential discounting and a constant discount rate has been criticized, when used to appraise long-term public projects. The critiques are motivated for the scarce importance this model attaches to the consequences of a certain project in the distant future and so to future generations. For this reason, several authors have approached the discounting process in a different way, taking into account variable discount rates and new discounting functions. In this paper, we have tried to include all the relevant contributions on the searching of an appropriate social discount rate, offering an overview of the research in the area.

Keywords Social Discount Rate, Long-Term, Public Project Appraisal.

JEL Classification H43, Q01.

1 Introduction

This paper is focused in the problem of discounting in the evaluation of long-term public projects. To appraise these projects, the cost-benefit analysis has been generally used, by means of the net present value method with an exponential discounting function and a constant discount rate. When dealing with public projects, specially projects with a long-term horizon, we must adopt a social cost-benefit analysis that implies the valuation of tangible and non tangible costs and benefits and the use of a social discount rate. Price (1988) defines the social discount rate like the discount rate used by the society to give relative weight to social consumption or income accruing at different points in time. Traditionally, there have been used, mainly, two references to calculate the discount rate, namely the *social opportunity cost rate of capital* and the *social time preference rate*. The social opportunity cost of capital is usually identified with the real rate of return earned on a marginal project in the private sector. The social time preference rate is the rate of fall in the social value of consumption by the public. It is also known as the consumption rate of interest. Cost-benefit analysis involving projects with long-term horizons have been long criticized for giving too little importance to future effects of policies and, therefore, to future generations. When using the exponential discounting, there is an undervaluation of distant future events due to the geometric reduction of the function $(1 + i)^{-t}$. Nonetheless, the cost-benefit analysis is, nowadays, the main tool for the economic evaluation of public projects in the administration of natural resources, as projects for flooding control, irrigation, port ameliorations and alternative projects of energy supply (Field (1995)). Cost-benefit analysis (CBA) of investment projects is explicitly required by the European Union regulations for projects that imply important budget consumption¹. The European Commission establishes, as performance indicators for the CBA, the net present value (NPV), the internal rate of return (IRR) and the Benefit-Cost ratio. To calculate the NPV, is specified the use of

¹ European Commission (2001).

the exponential discounting model and it is proposed a 5% European social discount rate as a standard benchmark for co-financed projects. However, in specific cases, it could be justified, by project proposers, a different value. Also, the governments of the European countries propose different values for the SDR. For example, the United Kingdom recommends in *The Green Book*² a SDR of 3.5%, based on the calculation of the social time preference rate. It also establishes a decreasing sequence of rates for projects with very long-term impacts (more than 30 years), and the circumstances where exceptions to the recommended rates are allowed. This rate is an update of the previous rate of 6% set in 1997. This revision is justified by the UK government because of the big changes in macroeconomic conditions, including the low interest rates and the need of a major orientation to the long-term in public projects appraisal. In the same way, in France the discount rate set by the Commissariat Général du Plan has recently been updated³ and lowered from 8% to 4% (both in real terms). However, the later figure does not include risk. It has been established also a decreasing discount rate for very long-term evaluations (horizons of more than 30 years) with a 2% discount rate as a minimum. In Italy, according to the new guidelines for feasibility studies⁴, the social discount rate is set at 5%. In Spain, different values of the social discount rate have been set depending on the sector involved: 6% in real terms for transport⁵, and 4% for water resource projects⁶. The USA also offers guidance for public projects appraisal in the Circular A-94⁷, recommending the use of the CBA for analysis of government programs or projects. The standard criterion for deciding whether a government program can be justified on economic principles is the net present value. For the CBA, a real⁸ discount

² Her Majesty Treasury (2003).

³ Commissariat Général du Plan (2005).

⁴ Conferenza dei Presidenti delle Regioni e delle Province Autonome (2001).

⁵ Ministerio de Transportes, Turismo y Comunicaciones (1991).

⁶ European Commission (2001).

⁷ Office of Management and Budget (1994).

⁸ Inflation is not included.

rate of 7% is proposed to value these projects and also sensitivity analyses with different discount rates are proposed. Nevertheless, there are areas of evaluation exempted from the scope of this Circular: water resource projects (guidance for which is the approved *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*); the acquisition of commercial-type services by Government or contractor operation (guidance for which is OMB Circular No. A-76), and federal energy management programs (guidance for which can be found in the Federal Register of January 25, 1990, and November 20, 1990). So, different discount rates are employed for projects of different nature. For example, the discount rates for water resource projects are updated annually and the recommended rate for 2007 is 4.875%⁹. The typical method for valuing the future effects (positive and negative) of an alternative public policy is by means of a constant annual discount rate. ‘This may be for reasons of its tractability as well as for concerns as to the normative status of non-constant discounting models’¹⁰ (Harvey, (1994)). Another advantage is the ‘rationality’ of preferences (time-consistency). Nevertheless it has been criticized for giving too little importance to the future effects of the policies analyzed and so for not giving the required importance to the effect on future generations. As a consequence, the valuation model usually used has been questioned and several authors have given another vision of discounting, taking into account variable discount rates and investigating other shapes for the discount function, different to the traditionally used exponential function. Harvey (1994) examines ‘the reasonableness for public policy analysis of non-constant discounting method that, unlike constant discounting, can accord considerable importance to outcomes in the distant future’. In his work he proposes a method with positive discount rates that decrease and converge to zero as time converges to infinity. Weitzman

⁹ Data available in the web of the Natural Resources Conservation Service, US Department of Agriculture.

¹⁰ Nevertheless, Harvey then states: ‘If future interest rates could be accurately predicted, then cost-benefit theory would recommend the use of these differing rates in a timing preference relation and thus the use of non-constant discounting’.

(1994, 1998) finds that taking the SDR constant over time is an inappropriate assumption, for a world seemingly evolving towards an ever increasing degree of environmental concern. He argues in favour of ‘a social rate of return that is not only lower than the private rate of return, but that is expected to decline systematically over time’. This is specially important in environmental projects, since higher discount rates make people more receptive to invest their resources in programs with relatively high payments in the short term, while, on the contrary, lower discount rates will lead people to choose programs with higher net benefits in the distant future. The problem is that any social discount rate based on present consumer rates or the rate of return on investment is likely, historically speaking, to exceed the economy’s growth rate (Henderson and Langford, (1998)). This means that ‘however small the cost today of preventing some catastrophic economic or environmental event in the future, if this catastrophe is sufficiently distant in time, the calculus of benefit-cost analysis will recommend against mitigative measures today’ (Lind, (1990)). So, the environmental problem will be relegated generation after generation, having the intergenerational dilemma described by Lind (1990). The economic literature on discount rates (no discounting vs. discounting and constant vs. variable discounting) is summarized in Fig. 1. In the following sections we are going to analyze these contributions that offer an overview of the different approaches to the problem of discounting and the finding of the appropriate social discount rate.

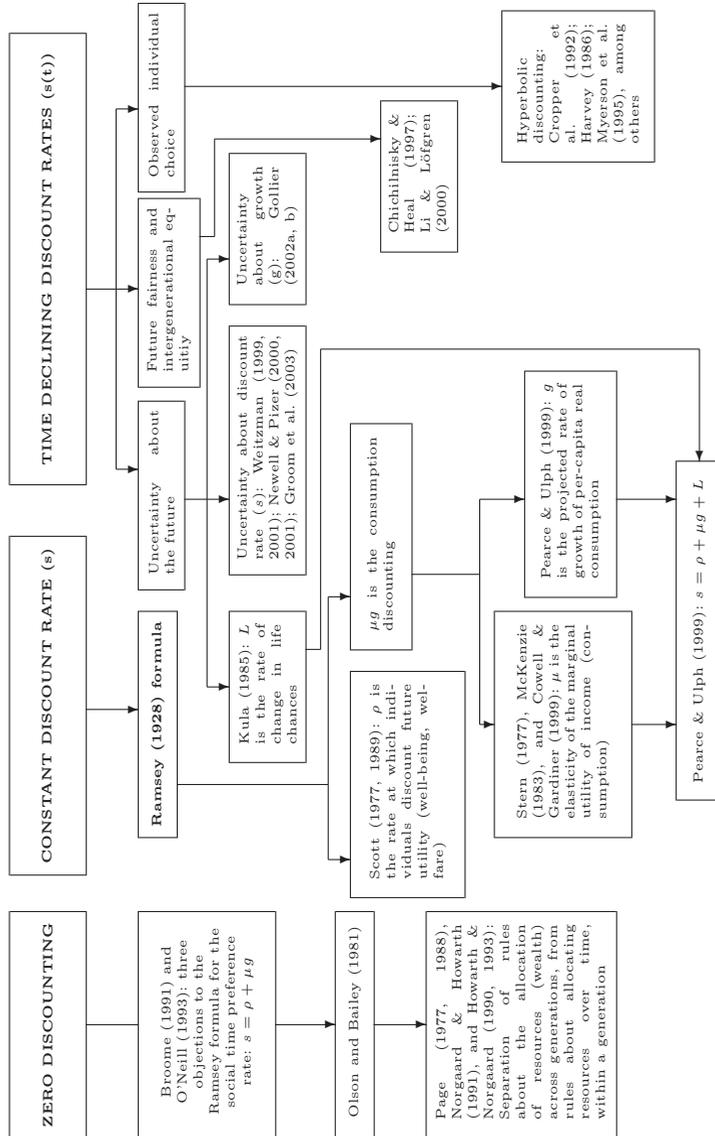


Fig. 1: Economic Literature on discount rates. Source: Oxera (2002) and own elaboration.

2 The constant discount rate and the proposal of zero discounting

The standard formula to calculate the social discount rate based on the social time preference is given by the Ramsey equation (Ramsey, 1928):

$$s = \rho + \mu g,$$

where¹¹:

s = the social discount rate,

ρ = the pure time preference rate¹², or rate at which individuals discount future utility (well-being, welfare). It reflects people impatience. Scott (1989) derives an estimate of this parameter that is set at $\rho = 0.5$.

μ = elasticity of the marginal utility of income (consumption). It is the change (percentage) in the well-being derived from a change (percentage) in income (or consumption). Stern (1977), McKenzie (1983), and Cowell & Gardiner (1999) offer a more detailed approach to this parameter.

g = mean rate of income growth or expected rate of growth of per capita consumption. Pearce and Ulph (1999) propose a variation of the Ramsey formula in order to include the rate of change in life chances (L), that is, they include the risk of death: $s = \rho + \mu g + L$.

Authors as Broome (1991) and O'Neil (1993) criticize the use of positive discounting and adduce three objections to the use of the Ramsey formula for the social time preference rate:

1. Reject pure time preference (ρ), because discounting across generations is different than discounting within his or her own lifetime.

¹¹ For a more detailed analysis of the parameters of the Ramsey formula see Pearce and Ulph (1999).

¹² Price and Nair (1985) noted, however, that the validity of including the pure time preference element is increasingly being called into question, particularly in relation to intergenerational equity. Even Ramsey himself suggested that the pure time preference part of the social discount rate should not be used by public policy-makers.

2. μg will be negative, since future generations will be worse off (regarding the availability of natural resources).
3. Uncertainty about the future should not enter in the discount rate.

Page (1977, 1988), Norgaard & Howarth (1991), and Howarth & Norgaard (1990, 1993) subscribe to the first objection that is the most important message from the critiques of positive discounting and they propose the separation of rules about the allocation of resources (wealth) across generations, from rules about allocating resources over time, within a generation. In the same way, Kula (1997) and Bayer (2003) distinguish between intragenerational and intergenerational discounting.

Olson and Baley (1981) establish that ‘An infinite time horizon and a zero rate of time preference suggest that (if the foreseeable rate of economic growth is less than the expected long-term rate of interest) current consumption would be no higher than the subsistence level’. While lowering the discount rate appears to take account of the well-being of future generations, it implies bigger and bigger sacrifices of current well-being. The logical implication of zero discounting is the impoverishment of the current generation.

3 Time declining discount rates

According to Pearce *et al.* (2003), ‘new work suggests powerful reasons why the discount rate is not a single number, but a number that varies in a declining fashion with time. This result emerges from several approaches: from an analysis of how people actually discount the future (hyperbolic discounting); from the implications of uncertainty about the future (the Weitzman and Gollier approaches); and from an explicit attempt to replace the traditional ‘present value’ maximand of policy appraisal with one that incorporates that goal along a sustainability requirement’.

3.1 Uncertainty about the future

3.1.1 Uncertainty about discount rate Weitzman (1999) considers that discount rates are uncertain and persistent. For Weitzman, the uncertainty is the absence of certainty about the weights assigned to future. As the weights are discount factors, it should be calculated the mean of the probabilistic discount factors. This process will produce time decreasing discount rates. In Newell and Pizer (2000, 2001), it is shown that, when the future path of interest rates is uncertain and persistent, the distant future must be discounted by lower rates than suggested by current rate. Their belief is that the past behaviour of interest rates over long periods of time ought to form the basis for predicting their future behaviour. They use USA bond historical data to quantify, by means of econometric methods, the uncertainty about future discount rates. So, for a period of 200 years, they offer certainty-equivalent rates (discount rates) from 4 to 0.5 per cent as time increases.

In spite of they both assume that interest rates are uncertain and persistent, for Weitzman (2001) the uncertainty represents the lack of current consensus about the correct discount rate for all periods. Newell and Pizer in contrast assume that ‘there is a reasonable consensus about the current discount rate today based on market rates, but this rate is likely to change over long periods of time’. So, they find that the source of uncertainty is the future. This approach was criticized by OXERA (2002): ‘Newell and Pizer’s statistical approach contained some weaknesses -for example, it could not test robustly for crucial aspects of interest rate behaviour, such as whether the path of interest rates followed a random walk or were mean reverting’. The paper of Groom *et al.* (2003) is based on the Newell and Pizer’s approach in determining declining discount rates: i) as they believe that the past is informative about the future is important to characterize the past as accurately as possible by correctly specifying the model of the time series process, and ii) selection among the models is also an empirical question.

3.1.2 Uncertainty about growth Weitzman (1999) and Gollier (2001, 2002a, 2002b) treat the uncertainty about the future. For Weitzman, that uncertainty is reflected in uncertainty about future interest rates. However, Gollier considers the uncertainty about the state of the economy and determines the socially optimal discount rate for long-term public investment projects. To do this, he supposes an exogenous process consisting of a stochastic growth of the consumption per capita. Gollier shows that there are two opposite effects that have an influence on the overall discount rate: first, the effect shown by μ in the Ramsey formula, and second, the precautionary saving or prudence effect that declines the value of the discount rate.

In OXERA (2002) is pointed that the difficulties in implementing the Gollier approach are numerous, as many of the parameters necessary to specify the variation of the discount rate over time are unknown.

3.1.3 Uncertainty about life chances Some authors like Kula (1984, 1985), following the proposals of Fisher (1930), Eckstein (1957), Henderson (1968) and Dasgupta and Pearce (1974), estimate the pure time preference rate starting from the calculus of the life expectancy and its projection to the investment time horizon. Kula (1984) establishes that ‘each member¹³ discounts the utility of future consumption by the probability of being alive to enjoy it’. Kula (1997) proposes a new discounting model: the Modified Discounting Method (MDM) that is applied in his book to different public projects (as afforestation, land drainage project, waste isolation plant). The appropriate rate of discount in the modified discounting method is the social time preference rate (STPR). This rate is assumed to contain the pure time discount rate, risk (in particular risk of death) and diminishing marginal utility of increasing income. Kula obtains the STPR based upon the annual risk of death and the diminishing marginal utility of income. In the MDM, the communal decision-maker estimates the number of

¹³ Kula (1984) makes in this work a study of social time preference rates of two communities (U.S. and Canada). ‘Each member’ refers to member of these communities.

generations who will be associated with a particular project and time frames involved. The well-being of each generation is discounted from its birthdate instead of a fixed point in time (generally the beginning of the project). In the same way, Bayer (2003) develops the Generation Adjusted Discounting (GAD) that implies taking into account an intragenerational discount rate (according to the Ramsey formula) and a intergenerational discount rate, smaller than the conventional one. In Bayer and Mery (2006) we find an empirical application of the GAD to two municipal solid waste disposal technologies. Both methodologies, MDM and GAD, could be also included in the following section as they take into account sustainability criteria and intergenerational equity. We could also include in the current section the hazard rate approach (Azfar (1999), Cruz and Muñoz (2005, 2007), Green and Myerson (1996) and Sozou (1998)). In certain occasions, receiving an amount depends on the performance of an event. So, the risk included in the discounting function can be considered as the hazard rate of the group (mortality or in general the reliability of a system).

3.2 Future fairness, intergenerational equity and sustainability

The following contributions from Chichilnisky and Heal (1997) and Li and Löfgren (2000) derive from the social choice literature and introduce the notion of intergenerational equity and sustainability¹⁴. Chichilnisky (1996) has proposed an interesting criterion that maximizes the weighted sum of two terms:

1. A discounted present value of the utility stream over an infinite time horizon.
2. An undiscounted long-run utility level beyond the infinite time horizon.

With these two terms representing the dictatorship of the present and the dictatorship of the future, she has shown that an objective function consistent of the sum of them avoid either of the two dictatorships. In Chichilnisky (1997) the

¹⁴ Heal (1998) states that ‘sustainability is above all about what happens in the long term: about whether we can continue ‘forever’ as we are, and whether the economic rules of the game lead us to make choices that are viable in the long term’.

conditions of no dictatorship of the present and of the future are defined in two axioms that capture the idea of sustainable development.

On the other hand, according to Chichilnisky and Heal (1997), social choice seeks ways to aggregate individual preferences into social preferences. They construct a social choice rule as follows. Suppose that an infinite sequence of individual preferences has a limiting preference. Then they simply select that limit as the social preference.

One then attempts to extend this map to all sequences of preferences, whether or not they have limiting preferences, maintaining important properties: the Pareto property and the non-dictatorship properties remain. The extension to all sequences of preferences is achieved by choosing, as a social preference, a point of accumulation of individual preferences. But the result of this selection depends on the order in which the preferences are listed. Having an infinite population means that there is no 'last agent'. With only a finite number, this rule selects the preference of the last agent, who is then a dictator.

Li and Löfgren (2000) assume that society consists of two individuals: a utilitarian and a conservationist, each of which make intertemporal decisions using different rates. They attempt to formalize a model of sustainable resource management reminiscent of the Chichilnisky formulation. They formulate the resource management problem as maximizing the weighted sum of the present value of two utility streams, i.e., one with a constant and positive discount rate (a representative of the present) and the other with a zero time discount rate (a representative of the future). The resulting model presents a discount rate declining over time towards zero.

They solve the conflict between present and future generations in a dynamic renewable resource model under a social welfare function introduced by Chichilnisky. The technical difference between Heal's model and theirs is that, unlike Heal's, it allows an unbounded present value of the utility streams.

3.3 Observed individual choice

Several authors have empirically shown that people do not discount at a constant exponential discount rate and most of them agree about the path followed by discount rates along time. For example, Cropper *et al.* (1992) carry out a survey of the preference between saving lives programmes¹⁵. Their purpose was to ask people to choose between two programs that (generally) benefit persons in different generations but whose costs are borne by the present generations. They found that people do not discount at a constant exponential rate and also that there was considerable heterogeneity in discount rates. From Cropper *et al.* (1992) empirical work discount rates of 0.168; 0.112; 0.074; 0.048 and 0.038 are deduced for different delays: 5, 10, 25, 50 and 100 years, respectively. So, discount rates are much higher for short horizons than for long ones¹⁶. Benzion *et al.* (1989) conducted an intertemporal choice experiment with 204 students of economics or finance. The subjects had to answer a questionnaire in which they found four scenarios (postponing a receipt, postponing a payment, expediting a receipt, expediting a payment) for different time delays (0.5, 1, 2 and 4 years) and different size of cash-flow (4, 200, 1000 and 5000 dollars). They found that the empirical discount rates declined as the time necessary to wait increased. For example, for an amount of 200 dollars, the discount rates inferred were 0.428, 0.255, 0.230 and 0.195, being the delays 6 months, 1, 2 and 4 years, respectively. This result supports the previous findings reported by Thaler¹⁷ (1981) about declining

¹⁵ They asked questions similar to the following: ‘The government has to choose between two programs that cost the same, but there is only enough money for one. Program A will save 100 lives now. Program B will save 200 lives 50 years from now. Which program would you choose?’

¹⁶ They note that their findings should be regarded as preliminary for reasons as the survey design (telephone interviews are seen as an imperfect vehicle for eliciting preferences over such difficult choices).

¹⁷ He conducted an experiment consisting in a set of questionnaires to be answered by University students with different options of amount (positive and negative) and delay. The implicit discount rates inferred from experimental choices declined as the length of time increased.

discount rates. In the same way (but from a theoretical approach), Harvey (1994) proposes a strictly decreasing discount function, with the objective of giving a greater importance to future costs and benefits of an investment project.

There are many empirical works that try to find the mathematical function that best fits the subject behaviour of discounting future rewards. Recently, in an increasing number of works the constant (standard) discounting and so the exponential discounting function has been substituted by the hyperbolic model. Most of these contributions have been made in the field of the behavioural psychology (Cruz and Muñoz, (2004)), although the results about choices that imply discount of delayed rewards can be applied in the economic field for discounting investment project flows. Laibson *et al.* (1998) and Angeletos *et al.* (2001) study decisional models of consumption/saving, using exponential and hyperbolic discounting and demonstrate that hyperbolic functions can explain better a set of empirical observations. The result of Green and Myerson (1996) empirical work points to a hyperbola-like function as the model that best explains temporal discounting at individual as at group level. The same result has been obtained in their previous work (Myerson and Green, (1995)). Several authors have proposed in their works hyperbolic or hyperbola-like discount functions: Azfar (1999), Ainslie (1975), Green, Myerson and Ostaszewski (1999), Harvey (1986), Henderson and Bateman (1995), Herrnstein (1981), Kirby (1997), Kirby and Marakovic (1995), Laibson (1997), Loewenstein and Prelec (1992), Mazur (1987), Myerson, Green and Warusawitharana (2001), Prelec (1989), Rachlin *et al.* (1991), Richards *et al.* (1997).

Frederick *et al.* (2002) make an interesting review of empirical research on intertemporal choice, providing an excellent overview of the multi-motive models of discount rates. They also show a resume of the empirical estimates of discount rates in 42 studies (experimental and field studies) with different features (time horizon, real or hypothetical and monetary or non-monetary goods to discount and different elicitation methods).

Kenley and Armsted (2003) make a specific revision of the literature on long-term discount models, providing the discount factors for different delays, according to the discounting model proposed in each paper. And they distinguish among exponential, hyperbolic, relative and proportional. (Relative and proportional discounting can be included in hyperbolic discounting, depending on the value of certain parameters of the model).

But this evidence has been also criticized by other authors (Mulligan (1996), Rubinstein (2003), Harrison (et al. (2002, 2005)) that question the methodology employed in empirical studies about hyperbolic discounting. Furthermore, Harrison *et al.* (2002,2005) found empirical evidence supporting constant discount rates concluding that in appropriately controlled and financially motivates settings, human behaviour is consistent with conventional exponential preferences. But they obtain this result from studies with relatively short-term horizon (the longest horizon used in their experiments is 36 month) and they do not focus on the evaluation of long-term public projects. Rubinstein (2003) points that, in spite of the availability of this analytic frame of work, few economists have studied the implications of hyperbolic discounting functions. He presents an alternative approach by applying similarity relations because he argues that the same argument against constant discount utility functions can be used against hyperbolic discounting: the evidence obtained from experimental observations. And he shows three experiments in which results are inconsistent not only with constant discounting but also with the hyperbolic one.

But the main critic to hyperbolic discounting, and in general to any model with time-varying discount rates, is time inconsistency, defined by Strotz (1955). Briefly, the time inconsistency means a reversion of preferences when varying the point of reference. Constant discount rates are, on the contrary, time-consistent¹⁸. This property 'might be argued should characterise rational social decision-making' (OXERA (2002)). Henderson and Bateman (1995) argue that these preference

¹⁸ It was first demonstrated by Strotz (1955).

reversals are, nonetheless, frequently observed and considered rational in behaviourist research. (Their explanation is that people treat their position in time as relative, not absolute and they find the process of changing the discount rate as time moves on as legitimate.) When considering projects with long and very long term profiles, we also find the intergenerational dilemma, described by Lind (1990) as follows: 'Suppose we select a social discount rate based on present consumer rates or the rate of return on investment. Historically, any such rate is likely to exceed the rate of growth of the economy, often by a large amount. Then the basic arithmetic of exponential growth applied in a cost-benefit analysis implies that, regardless how small the cost today of preventing an environmental catastrophe that will eventually wipe out the entire economy, it would not be worth this cost to the present generation if the benefits in the future are sufficiently distant'. In this way, the environmental problem will be relegated generation by generation. This is an important question, since 'our social decisions will affect the quality of life in the distant future and thus for the future generations' (Harvey (1994)). Following the reasoning of Pearce and Turner (1995), higher discount rates will imply a greater discriminating treatment of future generations. Firstly, projects with social costs in a distant future and net social benefits in short term will probably be accepted after cost-benefit analysis when used discount rates will be greater. So future generations will support a disproportionate part of the project costs. Secondly, projects with social benefits in the long run have a lower probability of being favoured by the cost-benefit analysis if discount rates are high, so most part of project benefits are being denied to future generations. Thirdly, when higher the discount rate, lower the general level of investment, and then the capital 'inherited' for future generations will be lower. The most probable situation is that discount rates fixed by the market will be unfavourable to future generations, since these rates are based on actual generations' preferences and/or in the productivity of capital. For this reason, the social discount rate must be different from private discount rate and, as high rates discriminate fu-

ture generations, the social discount rate must be lower than the private discount rate fixed by the market.

4 Conclusions

In this paper we present an overview of the relevant literature about the social discount rate (SDR) to be applied in the evaluation of long-term public investments. There is an increasing number of papers on this research area - theoretical and empirical, focused on short-term and long-term investments, on private and public investments, approached by psychologists as well as by economists - reflecting the interest and controversy that the discounting subject causes nowadays. For this reason, we are aware that it is impossible to include all of them in a revision, but we have tried to include the main contributions regarding the SDR on long-term public appraisals. There are important critiques to the standard use of the cost-benefit analysis with a constant discount rate and many authors have offered alternative approaches, mainly proposing declining discount rates models that are not exempt from objections. So, further research is needed to clarify and to strengthen the justification of any new discounting model for public projects. The weight of evidence in favour of any new discounting function must be convincing before government agencies will decide to use a new discounting function or a new practice in project appraisals. Nevertheless, there are important reasons as future fairness and intergenerational equity that force us to question the current discounting practices and it is encouraging to see that some governments (as UK and France) have acknowledged the power of the arguments for time-varying discount rates in long-term public projects appraisal.

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