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A Proposal for a New Prescriptive Discounting Scheme: The Intergenerational Discount Rate

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Summary

Cost-benefit analyses require comparing costs and benefits that occur at different points in time. Doing so, however, creates conflicts between short-term considerations — a discounting scheme has to be consistent with observed behaviours — and long-term ethical issues — a discounting scheme must not favour the current generation over future ones. To overcome this conflict, the present article proposes a prescriptive consumption discounting scheme that applies different discount rates (i) for various incomes in the lifetime of a unique individual and (ii) for various incomes that affect different individuals. Practically, any income flux is first discounted to the birth date of all individuals using a discount rate with a non-zero pure preference for the present; then these individual discounted values are discounted to the present with a discount rate with no preference for the present and finally summed up. The aim of this prescriptive discount rate is to be consistent with observed individual behaviour (descriptive discount rate) without favouring current generations. Consequences are discussed and compared with the UK Green Book and the Stern Review discounting schemes.

Keywords: Discount Rate, Intergenerational Equity

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1 Introduction

Cost-benefit analyses often require comparing costs and benefits that occur at different points in time. This comparison is done using a discount rate, which reflects the fact that benefits and costs that occur earlier are valued more than remote ones. This difference in valuation is observed in money markets.

For social projects, e.g. climate change mitigation, however, the use of market interest rate as discount rate is heatedly questioned (see a review in Toth, 2000). In the UK, for instance, the "Green Book, Appraisal and Evaluation in Central Government" (http://greenbook.treasury.gov.uk/) proposes several consumption discount rates that depend on the considered time horizon (see Tab. 1). The decreasing value of the discount rate is justified by the uncertainty on future consumption (see Weitzman, 2001; Gollier, 2002).

In the Stern Review on the Economics of Climate Change (Stern, 2006), the discount rate — averaged over the 1000 simulations that were carried out — was very low, at 1.4 percent. This low value, which was criticized by Maddison (2006) and Weitzman (2007), was justified by the ethical position that the welfare of future generation should not be valued lower than the welfare of current generation. In that sense, the discount rate cannot be the same in a situation where only one generation is affected and in a situation where several generations are affected: one generation can value lower its own welfare in the future, but can hardly justify valuing lower the welfare of another generation.

2 The discount rate

In a prescriptive framework, assuming a baseline scenario where real consumption is growing at a fixed rate[2], the consumption discount rate[3] is given by the following relationship (Ramsey, 1928):

$$\delta = \rho + n \cdot g \ , \tag{1}$$

[2]Note that the consequences of the project under consideration should not be large enough to lead to a change in growth rate. In other terms, this relationship can be applied only to projects with no influence at the macro level (Heal, 2005).

[3]This discount rate is referred to as "consumption discount rate" because it is applied to a flux of consumption not to a utility flux.

Period of the years	0-30	31-75	76-125	126-200	201-300	301+
Discount rate	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%

Table 1: Discount rate of the Green Book, as a function of time.

where δ is the consumption discount rate; ρ is the pure preference for the present; g is the growth rate of real consumption per capita; n is the elasticity of the marginal utility of consumption, i.e. the change in marginal utility of consumption when consumption increases by 1 percent.

The parameters n et g represent the fact that one euros will provide less utility in the future, because consumers will be richer then, and one euros will represent a smaller fraction of their income. These parameters are used to translate changes in monetary values into changes in welfare levels. The Stern Review assumes that n=1 and g=1.3 percent, while the Green Book assumes n=1 and g=2 percent. Weitzman (2007) proposes to use n=2 and g=2. These differences show that there is little agreement on the numerical values of these parameters.

The parameter ρ represents the fact that individuals value lower their welfare in the future than their present welfare. It represents, therefore, their impatience. This parameter is used to compare welfare levels, not monetary values. Over the short-term, observations suggest values ranging from 1 to 3 percent. The application of these rates to long term issues, however, leads to ethical problems, since it means that the welfare of future generations is less important than the welfare of current generations.

For this reason, the Stern Review decided to use a value of ρ at 0.1 percent, assumed to be the annual probability of catastrophe eliminating society. Here, the only reason why welfare of future generations is valued lower is the possibility that these future generations may not exist. The prescriptive discount rate proposed in the Stern Review, however, contradicts individual behaviours and descriptive discount rates (see, e.g., Weitzman, 2007).

As a consequence, we are looking for a discounting scheme that takes into account the facts that (i) we observe that individuals use a non-zero pure preference for the present in their every-day choices ($\rho > 0$); and (ii) there is no reason to apply a pure preference for the present to future generations. This article proposes a scheme to do so. To focus on the main point of the paper, we assume that there is no uncertainty on future consumption — making the Green Book argument for a decreasing discount rate irrelevant — and that there is no risk of catastrophe threatening mankind.

3 A new scheme to discount over the long term

The prescriptive discounting scheme proposed in this paper, hereafter referred to as the intergenerational discount rate, considers a given, certain flux of income, with an income $C(i)$ each year i. It aims at assessing the net present value of this flux. This discount rate is, therefore, a consumption discount rate, not an utility discount rate, which discounts utility levels.

In the scheme proposed here, as suggested by Hunt and Taylor (2008), we do not discount current-generation consequences at the same rate as intergenerational consequences. To do so, we consider each individual separately. The flux of income that each individual will receive is first discounted to the birth date of this individual. This discounting is done using the usual discount rate, which takes into account a non-zero pure preference for the present and the effect of economic growth and is consistent with observed behaviours.

Then, these discounted values are discounted to the present and summed up. Since this second discounting phase considers different individuals, born at different times, there is no reason to consider a non-zero pure preference for the present (especially because we disregard the risk that mankind may disappear). This second discounting is done, therefore, using a discount rate that takes into account only the effect of real-consumption growth.

We consider a population $P(i)$. Each year i, there are $p(i)$ new births, and each individual lives N years. We assume that the flux of income $C(i)$ is distributed homogenously among the individuals. Each individual has a flux of income $c(i) = C(i)/P(i)$.

We consider one individual, born during the year $i > 0$. The net value of his or her flux of income at his or her birth date is given by

$r(i)$, the discounted sum of income fluxes along his or her lifetime, with a discount rate that takes into account both the pure preference for the present (ρ) and the influence of real-consumption growth ($n \cdot g$):

$$r(i) = \sum_{j=0}^{N} c(j+i) \left(\frac{1}{1+\rho+ng} \right)^j , \tag{2}$$

where $j = 1, ..., n$ represents the age of the individual. Now, this net value can be discounted to the present. Since this discounting is done to a date that is before the birth of the individual, this discounting does not have to take into account the pure preference for the present, which would favour the current generation over the next ones. But it does have to take into account the fact that future generations will be richer than the current one. To do so, we calculate the net present value of the flux of income for this individual using:

$$r^0(i) = \left(\frac{1}{1+ng} \right)^i \sum_{j=0}^{N} c(j+i) \left(\frac{1}{1+\rho+ng} \right)^j \tag{3}$$

This relationship is valid for individuals that will be born in the year $i > 0$. For individuals who are born in the past, during the year i ($i < 0$), the relationship reads:

$$r^0(i) = \sum_{j=0}^{N+i} c(j) \left(\frac{1}{1+\rho+ng} \right)^j \tag{4}$$

For instance, an individual born 30 years before present ($i = -30$ years) has a net present value of the income flux equal to:

$$r^0(-30) = \sum_{j=0}^{N-30} c(j) \left(\frac{1}{1+\rho+ng} \right)^j \tag{5}$$

If we sum the net present value of individuals who are born already and of individuals who will be born in the future, we get the net present value R of the flux of income:

$$\begin{aligned} R \;=\; & \textstyle\sum_{i=-N+1}^{0} \left[p(i) \sum_{j=0}^{N+i} c(j) \left(\frac{1}{1+\rho+ng} \right)^j \right] + \\ & \textstyle\sum_{i=1}^{+\infty} \left[p(i) \left(\frac{1}{1+ng} \right)^i \sum_{j=0}^{N-1} c(j+i) \left(\frac{1}{1+\rho+ng} \right)^j \right] \end{aligned} \tag{6}$$

The first sum is for the population that is already living at t=0; the second sum is for the future population.

4 Example in a simplified case

To assess the consequences of using such a discounting scheme, we consider here a simplified example. We assume that the population is stable (P(i)=P), i.e. that there are as many deaths as births, so that the population is constant:

$$p(i) = p = \frac{P(i)}{N} = \frac{P}{N} \tag{7}$$

Then, we calculate the net present value of a flux of income that is constituted of one euro, received at the date k, and distributed evenly among the population: $C_k(j) = \delta_{jk}$ and $c_k(j) = \delta_{jk}/P$. The net present value of this flux of income is given by Eq.(5).

If $k \geq N$, nobody in the current population is affected. The net present value, therefore, is given by the second term of Eq.(5) only:

$$R_k = \sum_{i=k-N+1}^{k} p \cdot c_k(k) \cdot \left(\frac{1}{1+ng}\right)^i \left(\frac{1}{1+\rho+ng}\right)^{k-i} \tag{8}$$

If $k < N$, some individuals in the current population will be affected, and the net present value is given by:

$$R_k = \sum_{i=k-N+1}^{0} p \cdot c_k(k) \cdot \left(\frac{1}{1+\rho+ng}\right)^k + \sum_{i=1}^{k} p \cdot c_k(k) \cdot \left(\frac{1}{1+ng}\right)^i \left(\frac{1}{1+\rho+ng}\right)^{k-i} \tag{9}$$

These relationships can be simplified into:

$$R_k = \begin{cases} \left(\frac{1}{1+\rho+ng}\right)^k \cdot \frac{1}{N} \cdot \left[\sum_{i=k-N+1}^{k} \left(\frac{1+\rho+ng}{1+ng}\right)^i\right] & \text{if } k \geq N \\ \left(\frac{1}{1+\rho+ng}\right)^k \cdot \frac{1}{N} \cdot \left[(N-k) + \sum_{i=1}^{k} \left(\frac{1+\rho+ng}{1+ng}\right)^i\right] & \text{if } k < N \end{cases} \tag{10}$$

The first term $\left(\frac{1}{1+\rho+ng}\right)^k$ is the classical discounting scheme, with pure preference for the present and the effect of real-consumption growth. The second factor takes into account the fact that there is no reason to use a preference for the present when we consider future generations. When k is close to 0, R_k is close to the net present value calculated with the usual discount rate $(\rho + ng)$.

When $k > N$, R_k can also be written:

$$R_k = \left(\frac{1}{1+ng}\right)^k \cdot \frac{1}{N} \cdot \left[\sum_{i=0}^{N-1} \left(\frac{1+ng}{1+\rho+ng}\right)^i\right] \tag{11}$$

So, when k is larger than N, the net present value of the unit of income is *proportional* — but not equal — to the net present value using the discount rate $(1 + ng)$. It means that we do not include impatience (or preference for the present) when we compare incomes that will occur when the present generation is dead. Nevertheless, impatience plays a role when we compare income that occurs after the death of the present generation with income that occurs when the current generation is — at least partly — alive.

From R_k, one can derive an equivalent discount rate, the intergenerational discount rate, i.e. the discount rate that, if applied between the present and the year k, would make one euros in k years have a net present value of R_k:

$$\delta_k = \mathsf{exp}\left[-\frac{\mathsf{log}(R_k)}{k}\right] - 1 \tag{12}$$

Of course, δ_k varies with k:

- When k is close to zero, δ_k is close to $(\rho + ng)$, i.e. a discount rate that includes both pure preference for the present and the effect of real-consumption growth.
- When k tends to infinity, this discount rate tends to $(1+ng)$, i.e. to a discount rate with no impatience. It means that when we compare current income and income at the infinity, we do not apply any pure preference for the present.

This scheme, therefore, makes a transition between the observed short-term discount rate, usually high, and an ethically acceptable long-term discount rate, significantly lower. This transition is not justified by uncertainty, like in the UK Green Book, but by a fundamental difference between individual discounting and intergenerational discounting.

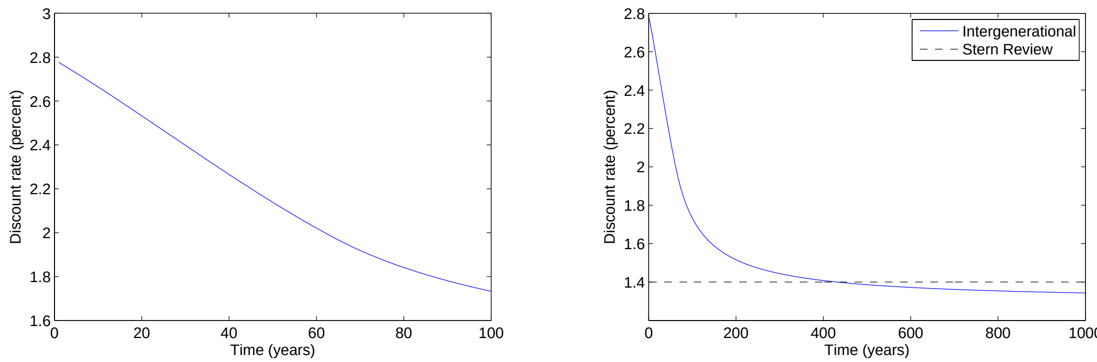

Figure 1: Intergenerational discount rate as a function of time, from 0 to 100 years on the left and from 0 to 1000 years on the right. Parameters for the intergenerational discount rate are those of the Stern Review for n and g, but the pure preference for the present is assumed equal to 1.5 percent.

5 Numerical application

In this numerical exercise, we will use the values from the Stern Review and from the UK Green Book. In both frameworks, n is assumed equal to 1, while g is equal to 1.3 percent in the Stern Review and 2 percent in the Green Book. In the Stern Review, the pure preference for the present is $\rho = 0.1$ percent, while in the Green Book, a value of 1.5 percent is used for short time horizons. With this data, the discount rate is equal to $r_s = \rho + ng = 1.4$ percent in the Stern Review, and $r_G = \rho + ng = 3.5$ percent in the Green Book for short-term projects.

To calculate the intergenerational discount rate, we assume that world-average life expectancy is 64 years (U.S. Census Bureau International Data Base). The result with the Stern Review parameters for n and g, and a pure preference for the present ρ of 1.5 percent, is reproduced in Fig. 1, which shows the discount rate over 100 years on the left, and over 1000 years on the right. Over one year, this discount rate is almost equal to the short-term discount rate of 2.8 percent. Over the very long-term, this discount rate is equal to the 1.3 percent, i.e. the discounting that arises from consumption growth only.

Figure 2 show the results with the Green Book parameters, with a discount rate that decreases from a short-term value of 3.5 percent

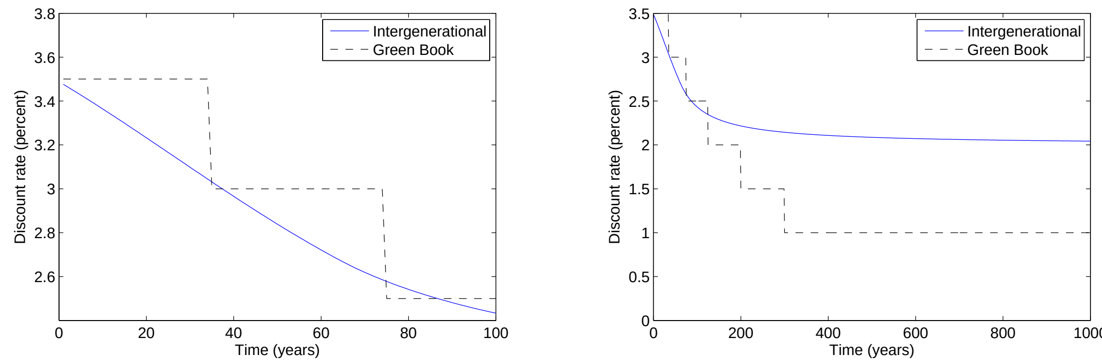

Figure 2: Intergenerational and Green Book discount rate as a function of time, from 0 to 100 years on the left and from 0 to 1000 years on the right. Parameters for the intergenerational discount rate are those of the Green Book, but assuming no uncertainty on future consumption.

to a long-term value of 2 percent. The final value is larger than the Green Book one because we do not take into account the uncertainty on future consumption. Taking it into account would lead to a much lower long-term discount rate.

6 Discussion

This paper proposes a prescriptive discounting scheme that applies different discount rates for various incomes in the lifetime of a unique individual and for various incomes that affect different individuals. It shows that it is possible to combine the consistency with observed behaviours and the ethical position that no generation should be favoured.

This scheme is not "time-consistent" (as defined in Heal, 2005), but this situation is justified by the fact that it is not the same persons that make decision at different point in time: some have passed away, some are born. Different individuals can make different decision without consistency issue (see also, Harvey, 1994).

Much can be done to sophisticate this scheme. For instance, it does not take into account the fact that the welfare derived from an income depends on the age of the individual. Additionally, we assume here that all individuals have the same life duration, and that this duration is known. Introducing uncertainty about life duration would be an important improvement. Also, the discount rate decrease depends here on population evolution. Using population scenarios would bring an additional sophistication to this scheme.

Most importantly, it has been highlighted by numerous authors (e.g., Weitzman, 2001; Gollier, 2002) that future consumption is uncertain, with important consequences on the discount rate. This point has been disregarded here and needs to be included. Including this uncertainty would lead to a discount rate that decreases even more rapidly with time.

This scheme can be expressed in terms of utility and utility discount rate, instead of consumption and consumption discount rate. In such a framework, the assumption of a given real-consumption growth rate could be relaxed. This discount scheme would not solve the issues discussed in Heal (2005), however, because it is equivalent over the very long term to a zero pure preference for the present, and the discounted sum of positive utility levels diverges.

As a consequence of these limitations, the discount rate proposed by this article is not supposed to be applied directly. This approach, however, provides an additional justification for the use of a consumption discount rate that decreases with the considered time horizon. For the climate change issue, it supports the use of low discount rates, as it has been done in the Stern Review.

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