A SOCIAL DISCOUNT RATE FOR CLIMATE DAMAGE TO FUTURE GENERATIONS BASED ON REGULATORY LAW

MARC D. DAVIDSON

Department of Philosophy, Faculty of Humanities, University of Amsterdam, Nieuwe Doelenstraat 15, 1012 CP Amsterdam, Netherlands
E-mail: m.d.davidson@uva.nl

Abstract. This article examines the implications for the social discount rate for damage due to climate change if risk to future generations is handled in accordance with the laws regulating our handling of risk to contemporaries. The conclusions are the following. Under current law, neither geographic distance nor differences in wealth between risk creator and risk bearer play any part in establishing a standard of 'reasonable care'. The concept of intergenerational justice requires these same principles to be applied in the intergenerational context too, implying a zero consumption rate of interest for climate damage. Assuming that the extent to which mitigation is at the expense of alternative investments is equal to society's marginal propensity to save, the social discount rate becomes society's marginal propensity to save times the long-term market rate of return on private investment, implying a social discount rate of around one per cent or a fraction of one per cent. This formula is exact under the assumption of average saving behaviour and by attributing consumption losses due to investment in damage prevention before damage occurs to the risk creator and after damage occurs to the risk bearer.

1. Introduction

In articulating policies to address climate change, governments are turning increasingly to cost-benefit analysis. One of the pivotal issues in such analysis is how to translate the benefits of climate policy, i.e. the climate-change-related damage prevented decades hence, into present-day monetary terms by means of a suitable *social discount rate*. Despite decades of debate, however, economists still disagree widely about the discount rate to be used for this purpose (see e.g. Lind, 1982; Arrow et al., 1996; Portney and Weyant, 1999). This controversy is one of the key reasons why recommendations on climate policy range from business-as-usual to radical changes to present production and consumption patterns (Arrow et al., 1996; Azar, 1998). Obviously, part of the controversy results from the issue being so morally charged. The generations creating the costs of climate change will most likely not overlap the generations bearing them. There now exists a vast literature in which economists and moral philosophers advocate a wide range of social discount rates based on various theories of justice and rationality, such as utilitarianism, egalitarianism or libertarianism. When contemplating how to handle climate costs to future generations, however, we can build on existing national and international laws prescribing how risks to our contemporaries are to be handled. As we shall see below, these laws establish certain boundaries for any debate about the social

Climatic Change (2006)
DOI: 10.1007/s10584-005-9018-x

discount rate to be adopted for the costs of climate change to future generations. Nevertheless, the possible relevance of current law for the discounting debate has been all but neglected to date (one exception being a short conference contribution by Shrader-Frechette (1998)).

The purpose of the present article is to examine the implications of current law for the social discount rate for consumption losses to future generations due to climate change. The term 'consumption losses' should be interpreted here in a broad sense, from reduced market purchases of goods and services like food and shelter to the fear of dying in a flood disaster. The term 'future generations' refers to all those not yet born. Thus, the first members of future generations will be born tomorrow, while in a hundred years' time almost everyone will belong to future generations from today's perspective. Due to the inertia of the climate system, any consideration of consumption losses due to climate change boils down to an evaluation of consumption losses to future generations.

This paper is structured as follows. In Section 2, I first explain the 'standard' theory of discounting and argue that the consumption rate of interest for climate damage may differ from the consumption rate of interest for changes in one's own future consumption. In Section 3, I point out that in the case of risk to our contemporaries, national and international law require us to give equal weight to consumption losses to the risk bearer due to damage and to consumption losses to the risk creator due to risk prevention. In Section 4, I argue that intergenerational justice requires a zero consumption rate of interest for climate damage and, in Section 5, that such an interest rate does not conflict with the principle of consumer sovereignty. After having clarified the resulting social discount rate with an example in Sections 6 and 7, finally, I draw some conclusions.

2. Economics of Discounting

2.1. 'STANDARD' THEORY

Discounting is a means of comparing costs and benefits that occur at different points in time. There are two basic reasons for discounting future costs and benefits. First, individual consumers prefer consumption today to consumption tomorrow, i.e. there is a positive consumption rate of interest. Second, capital investments enhance future production and consumption, i.e. there is a positive social return on investment.

Economists generally cite two motives for employing a positive consumption rate of interest (CRI). First, people expect to be wealthier in the future and that an extra dollar will therefore then matter less: rather an extra dollar today as a poor medical student than an extra dollar in twenty years' time as a well-paid surgeon. Second, people may simply prefer the present to the future, whether through 'weakness of will' (*akrasia*), erroneous overestimation of benefits accruing earlier

(*myopia*) or the uncertainty that one will still be alive in the future. Economists generally call this a 'pure' rate of time preference, or the utility discount rate. The CRI can thus be expressed as a sum of two terms (Ramsey, 1928; Koopmans, 1960; Arrow and Kurz, 1970):

$$\text{CRI} = \rho + \mu g \tag{1}$$

where ρ is the pure rate of time preference, μ the absolute value of the elasticity of marginal utility (a measure of the relative effect of a change in income on welfare), and g the expected growth rate of per capita consumption.

The marginal rate of return on private investment (MRRI) expresses the fact that capital is productive, i.e. that a dollar invested in productive activities rather than consumed will generate additional income and hence additional consumption in the future. There are therefore opportunity costs involved in investing money in one activity rather than another.

The interplay of the supply of savings and the demand for investment results in a market interest rate i. In a world without market failure, tax or risk one would write:

$$i = \text{MRRI} = \text{CRI} = \rho + \mu g \tag{2}$$

In this simplified world, the *social* discount rate, i.e. the rate to be used to calculate the present value of the costs and benefits of public policies, is simply the market rate of interest. When taxes introduce a hedge between the consumption rate of interest and the rate of return on private investment, determining the social discount rate is a complicated and somewhat controversial issue, first and foremost because investments will generally be partly at the expense of present consumption and partly at the expense of savings and alternative investments. The most thorough and theoretically correct approach to this problem is the shadow price of capital approach (Lind, 1982; see also Eckstein, 1958; Arrow and Kurz, 1970; Bradford, 1975). This method applies the CRI to both consumption and investment flows, after the latter have been converted to consumption equivalents using a shadow price of capital: the present value of the future stream of consumption benefits associated with one dollar of private investment discounted at the CRI (Lind, 1982, p. 39). The shadow price of capital approach allows one to use the CRI as the discount rate without ignoring the opportunity cost of displaced investment.

In principle, the shadow price of capital approach requires detailed information about the future consumption and investment flows associated with individual investment decisions. However, the approach is very much simplified if one takes average values for the economy as a whole. If case-specific information does not provide evidence to the contrary, it is reasonable to assume that the fraction of expenditure that is at the expense of alternative investments is given by society's *marginal propensity to save* (α), which most economists estimate to be around 20% (see e.g. Lind, 1982; Cline, 1992). For generic 'optimal policy' instruments such as

carbon taxes or systems of tradable emission rights, for example, this is a reasonable assumption (Cline, 1992). In the absence of contrary evidence it is, moreover, reasonable to assume that invested capital remains fully invested and that a fraction α of the returns on investment is reinvested (Lind, 1982). The social discount rate (SDR) then simply becomes the weighted average of MRRI and CRI (Krutilla and Eckstein, 1958; Haveman, 1969; Sandmo and Drèze, 1971; Harberger, 1972; see also Section 6):

$$\text{SDR} = \alpha\ \text{MRRI} + (1 - \alpha)\ \text{CRI} \tag{3}$$

In the following sections, I focus on the value of CRI to be used in the context of climatic change mitigation. The appropriate value for MRRI is a highly controversial subject in its own right, which I shall not discuss in this article (see e.g. Weitzman, 1998, 2001; Howarth, 2003; Newell and Pizer, 2003, 2004). Illustrative rates in government guidelines are seven percent by the US Office on Management and Budget (OMB, 1992), two to three percent by the US Environmental Protection Agency (EPA, 2000) and a declining schedule of rates starting at three-and-a-half percent by the UK government (HM Treasury, 2003).

2.2. THE CONSUMPTION RATE OF INTEREST FOR CLIMATE DAMAGE

In the above discussion of the social discount rate it has been assumed that people's consumption rate of interest does not depend on the nature of the change in consumption. The consumption rate of interest may be time-dependent, but at any given time it has been assumed to be the same for different goods. This assumption is not necessarily valid, however. People may well employ different consumption rates of interest depending on whose consumption is at stake and the cause of the change in consumption (see e.g. Eckstein, 1957; Marglin, 1963; Sen, 1982; Lind, 1982). To analyse the consumption rate of interest for climate damage, it is important to distinguish three situations in particular: 1. action today that changes one's own future consumption; 2. action today that changes someone else's future consumption, either by causing damage or by preventing damage one would otherwise cause; 3. action today that changes someone else's future consumption without causing or preventing damage. At this point in my argument I claim neither that people do in fact employ different consumption rates of interest for these different situations, nor indeed that they should. The only claim is that they potentially *can*. For example, people may either be indifferent to future generations and apply an infinite consumption rate of interest for changes in their consumption, or see reason to apply a zero consumption rate of interest. Even if it could be argued that to hold such different consumption rates of interest would be inefficient, immoral or irrational, it would not be *impossible*.

There are two reasons why I do not exclude the possibility of three different consumption rates of interest. First, people generally have both personal interests

and moral convictions, leading them to value changes in consumption differently depending on who they accrue to and what causes them. Most people, while preferring to win the lottery themselves rather than see a stranger do so, are prevented by a sense of duty from deriving equal enjoyment from the same amount of money acquired in a perfect crime. Furthermore, people may distinguish between negative and positive duties (see e.g. Feinberg, 1973). Negative duties are duties not to interfere with others, for example the duty not to harm others in health and property. Positive duties, on the other hand, oblige one to take action to help others, often through the mediation of the government. Examples here might include the positive duty to help others to obtain housing, work, health care, a pension or unemployment benefits. Generally speaking, people attach greater weight to the negative duty not to harm others than to the positive duty to help them (Pogge, 2002). Only a hypothetical 'pure utilitarian' would be immune to such differences and show the same preference towards every change in consumption, whether it be his or her own or someone else's. Once again I emphasise that at this point in my argument I wish to claim about people's moral views neither what they generally are nor what they should be, only that there is sufficient reason to analytically distinguish the three situations I have cited.

The second reason for distinguishing three different consumption rates of interest is that when considering measures to mitigate climate change, the change in consumption due to mitigated climate change does not accrue to the same person, but generally to people living in the (distant) future. After all, because of the inertia of the climate system the most adverse effects of climate change will probably not be felt in the coming decades but after half a century, say, by people who by and large are as yet unborn (Fankhauser and Tol, 1996; Mendelsohn and Neumann, 1999). Furthermore, the aim of mitigating climate change is to prevent dangerous *anthropogenic* interference with the climate system (UNFCCC, 1992), i.e. the adverse effects do not occur independently of our actions. Climate change is in fact a risk we impose on others, which means mitigation is more closely allied to negative than to positive duties. Consequently, the consumption rate of interest employed for climate damage may differ from that for the general benefits to future generations arising from investments in, say, knowledge or transport infrastructure.

For all these reasons, people may employ a specific pure rate of time preference for climate damage (ρ_{cd}) and a specific factor to account for eventual differences in per capita consumption between present and future generations (ν_{cd}), which may differ from the absolute value of the elasticity of marginal utility (μ). For the specific case of climate damage I therefore propose formula:

$$\mathrm{CRI}_{cd} = \rho_{cd} + \nu_{cd} g \tag{4}$$

Formula (3) for approximating the social discount rate thus becomes:

$$\mathrm{SDR}_{cd} = \alpha\ \mathrm{MRRI} + (1-\alpha)\ \mathrm{CRI}_{cd} = \alpha\ \mathrm{MRRI} + (1-\alpha)(\rho_{cd} + \nu_{cd} g) \tag{5}$$

Now it may be objected from the start that applying different social discount rates to different changes in consumption would be *inefficient*, i.e. not lead to optimal economic growth or maximisation of total social utility (see e.g. Nordhaus, 1994, p. 132; 1997). First, however, it should be noted that in formula (5) only $\nu_{cd} \neq \mu$ may be at the expense of efficiency if future generations indeed enjoy a higher per capita consumption. MRRI and α do not depend on the kind of change in consumption and to use a ρ_{cd} that differs from the pure rate of time preference for changes in one's own consumption only affects the inter-temporal distribution of utility. There may or may not be good *moral* reasons for holding a specific ρ_{cd}, but it is not *inefficient*. Second, it should be noted that although $\nu_{cd} \neq \mu$ may be at the expense of efficiency with respect to *utility* maximisation, it is not at the expense of efficiency with respect to *wealth* maximisation. As I shall argue in the following sections, there is good reason to accept such inefficiency with respect to utility maximisation in the context of climate change mitigation.

3. Legal Regulation of Risk to Contemporaries

In the following sections I focus on the value of CRI_{cd}, i.e. on the question of how to deal with temporal distance and differences in wealth between present and future generations. To answer this question, it is important to appreciate from the start that there are a multitude of legal regimes, private and public, laying down standards of behaviour for dealing with risks imposed on *contemporaries*. I should emphasise that I claim neither that these legal regimes are 'just' in a moral sense, nor that all societies adhere to the same legal systems. Laws may differ from country to country and from era to era. As I shall argue in the following section, however, the legal regimes guiding permitted behaviour among contemporaries, as they happen to exist in a particular country at a particular time, do matter for the consumption rate of interest for climate damage.

First, it should be noted that time discounting is in fact considered appropriate in tort law when assigning monetary damage awards in the case of latent harm or future losses of welfare due to an accident in the present (see e.g. Revesz, 1999). For example, people may be exposed to carcinogens and face the risk of disease twenty years later, or may have become disabled in a traffic accident and lose future wages. However, this practice of discounting is irrelevant for the discussion of CRI_{cd}. In the case of future harm to contemporaries, compensation is paid to the victim him/herself in the present, i.e. before the future costs occur. Since the victim is free to choose whether he/she diverts the damage award to present consumption or invest it to compensate for the future damage, current law allows future damages to be fully discounted at the marginal rate of return on private investment. In the case of climate damage, however, future generations can neither receive present damage awards, nor decide themselves how

to divert such awards. As a result, the social discount rate for climate damage should not only reflect MRRI, but also CRI_{cd} as argued in Section 2. I therefore turn to the question of how current law deals directly with *spatial*, rather than temporal, distance and with differences in wealth between risk creators and bearers.

Legislation seldom requires us to avert all risk of damage to other parties. Such an absolute demand would either be physically impossible to fulfil or would bankrupt society, and some risk, however small, will usually remain. Consequently, legislation generally requires people to take 'reasonable care' or 'due care' or keep risk to others as low as 'reasonably achievable' or 'practical'. Application of such standards inevitably involves some form of assessment, both of the risk itself and of the cost of alleviating it. In some instances legal formulations require a quantitative cost-benefit analysis. According to a famous ruling by judge Learned Hand (Hand, 1947), the defendant is found negligent if the cost of precautions is less than the damage multiplied by its probability.[1] Generally, however, judges undertake their task in a broad, impressionistic manner (Ogus, 1997).

Although a quantitative cost-benefit analysis seldom underlies interpretation of 'reasonable care', there are two conclusions to be drawn from present legislation that are important for the discounting debate. First, under current law geographic distance between the risk creator and risk bearer is not taken into account in setting the standard of reasonable care. Lack of interest in what happens farther away, or 'short-sightedness', does not qualify as an extenuating circumstance. Second, under current law differences in wealth between risk creator and risk bearer are not taken into account in setting the standard of reasonable care either (Arlen, 1992, 2000). No legal interpretation of 'reasonable care' is conceivable in which the risk creator explicitly characterises consumption losses by the risk bearer as less important on the argument that the risk bearer is wealthier than the risk creator. According to current law, the owner of a chemical plant, say, must spend the same funds on preventing damage to surrounding residences irrespective of the wealth of their owners.

It may be argued that differences in wealth are irrelevant because 'reasonable care' is simply an efficient rule with which to balance the marginal costs of risk mitigation and damage compensation. This is not the case, however. Under current law, differences in wealth are not only irrelevant for setting the standard of reasonable care in the case of strict liability, but also in the case of negligence liability. Strict liability is the responsibility to pay compensatory damages according to the amount of actual harm suffered by the plaintiff even if there is no (proof of) negligence, whereas negligence liability is the responsibility for compensatory damages only if there is indeed such (proof of) negligence. Particularly in the case of negligence liability it has been argued that making the standard of 'reasonable care' dependent on differences in wealth between defendant and victim would improve total social utility, following Marshall (1890), who noted that "a pound's worth of satisfaction to an ordinary poor man is a much greater thing than a pound's worth of satisfaction

to an ordinary rich man" (see e.g. Abraham and Jeffries, 1989; Arlen, 1992, 2000; Miceli and Segerson, 1995). However, legal-scientific debate about such adaptations has so far been without consequence for the standard of 'reasonable care' in current law (Arlen, 1992).

The laws according to which damage to others is not to be deemed less important when assessing 'reasonable care' hold not only within national borders but also when dealing with transboundary risks. International law forbids the owner of a chemical plant to offer less risk protection to people simply because they are living across the border. Neither does international law allow developing countries to discount damage to citizens in developed countries due to transboundary air pollution in cost-benefit analyses of preventive measures on the basis of differences in per-capita income between the countries. A landmark case in this context is the decision by the Trail Smelter Arbitral Tribunal (1941) between the United States and Canada concerning American farmers who had suffered damage from sulphur dioxide emissions by a Canadian smelter of zinc and lead ores located in Trail, British Columbia. The arbitral Tribunal declared that "no State has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another or the properties or persons therein, when the case is of serious consequence and the injury is established by clear and convincing evidence". Furthermore, the arbitral Tribunal agreed with a decision by the Federal Court of Switzerland between the Swiss cantons of Solothurn and Aargau (see Schindler, 1921, p. 174) that "no more precautions may be demanded ... near the boundaries of two cantons than are required ... in the interior of a canton." In other words, the precautions taken by a state in such a context should be no more and no less than those it would take to protect its own citizens. This responsibility for transboundary pollution has found its way into many contemporary treaties, primarily from its inclusion in the influential Principle 21 of the 1972 UN Conference on the Human Environment (Stockholm Convention), which declares that "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction." This principle was reaffirmed at the UN Conference on the Environment and Development (UNCED) convened in Rio de Janeiro in 1992.

In conclusion, when determining reasonable care in the case of risk to other *contemporaries*, national and international law require us to give equal weight to consumption losses to the risk bearer due to damage and to consumption losses to the risk creator due to risk prevention. These laws apply in equal measure to all the planet's present inhabitants, with neither spatial distance nor greater wealth of the risk bearer being acceptable grounds for discounting.

4. Intergenerational Justice

In the previous section I observed that most societies adhere to legal systems according to which risk mitigation by risk creators does not depend on the wealth or location of those bearing the risk. In this section I argue that consistency from the angle of intergenerational justice would require consistency between the consumption rate of interest for climate damage and existing legal systems guiding permitted behaviour among contemporaries. This would imply $\mathrm{CRI}_{\mathrm{cd}} = 0$.

Justice is difficult to define, but the formal requirement of justice, that equal cases be treated equally and different cases differently, is an important starting point for any policy on justice. Amongst other things, the requirement means that everyone should receive the same treatment under the law and the same treatment from the authorities. To treat people differently one must have *relevant moral grounds* (see e.g. Rawls, 1972; Shrader-Frechette and Persson, 2001).

In moral philosophy, the question of whether future generations have any moral standing and deserve to be treated as moral equals is a controversial one. Some moral philosophers have argued, for example, that there is no meaningful sense in which present generations can be held to harm future generations (see e.g. Parfit, 1984) or that people cannot have rights if they cannot claim them (see e.g. De George, 1979). I wish neither to defend such positions nor refute them. However, I do claim that if the concept of intergenerational justice is to have any meaningful content and practical value, then it should comprise the notion that norms, which today hold in equal measure for all contemporaries *and* which can be meaningfully applied in the intergenerational context, should hold for future generations as well. The norm according to which risk mitigation by risk creators should not depend on the wealth or location of risk bearers is one such norm, for which there are no relevant moral grounds for not applying it to future generations except by denying future generations moral equality. This implies $\rho_{\mathrm{cd}} = 0$, $\nu_{\mathrm{cd}} = 0$, and consequently $\mathrm{CRI}_{\mathrm{cd}} = 0$.

It is important to note that intergenerational justice does not imply a zero consumption rate of interest for *every* change in the consumption of future generations. As argued in Section 2.2, the consumption rate of interest may differ for changes in the consumption of future generations that are unrelated to damage prevention, such as those due to investments in education and long-term infrastructure. There is therefore no reason to fear "a situation where one was always ready to starve oneself in the present so long as there was any annual benefit however small to be derived from adding to the community's stock of capital" (Dobb 1960, p. 19; see also Koopmans, 1960; Olsen and Bailey, 1981; Pearce and Turner, 1990; Pearce et al., 2003).

It might be argued that a relevant moral ground for treating future generations differently is that we are already amply compensating them by the material and other benefits we bequeath them. However, the lion's share of these benefits is in the form of positive externalities: new technologies and useful artefacts created to improve

our own lives, for example, but still available to future generations when we are no longer around. Under current law, the existence of positive externalities cannot compensate or justify the existence of negative externalities. In particular, when the creator cannot exclude the beneficiary from the external benefits, there are no legal grounds for demanding compensation for those benefits. Consequently, the creator of external costs and benefits cannot cancel one against the other, either. There seems to be no justification for adopting a different approach in the intergenerational context.

It might also be argued that a relevant moral ground for treating future generations differently is the absence of an intergenerational income tax system (see e.g. Tullock, 1964; Baumol, 1968; Nordhaus, 1994, p. 123; 1997). In the intragenerational context it has been argued (by Kaplow and Shavell, 1994, for example) that the legal system should not aim for utility maximisation, as the income tax system is a more efficient means of achieving distributional goals. One might then easily jump to the conclusion that the current legal system does not take differences in wealth into account in setting the standard of 'reasonable care' because there is an income tax system. However, there is no indication that societies would have taken differences in wealth into account in present regulatory law if there had been no income tax system. International law regulating transboundary risks provides clear evidence of the opposite in fact, as no account is taken of transboundary differences in wealth despite the absence of an international income tax system.

Since I take intergenerational justice to imply treating future generations consistent with the institutionalised norms guiding permitted behaviour among contemporaries, I disagree with the various proposals for a $\mathrm{CRI}_{\mathrm{cd}}$ based upon ideal theories of justice and rationality (see for the latter e.g. Lagerspetz, 1999). Utilitarians, for example, advocate maximisation of utility (happiness or well-being) over time and therefore recommend $\rho_{\mathrm{cd}} = 0$, $\nu_{\mathrm{cd}} = \mu$, and subsequently $\mathrm{CRI}_{\mathrm{cd}} = \mu g$ (see e.g. Cline, 1992; Rabl, 1996).[2] In *A Theory of Justice* (1972) the political philosopher Rawls rejected utilitarianism and argued for a society in which the position of those who are least well-off is optimised (according to the 'maximin criterion' or 'difference principle'). Although Rawls himself saw reasons not to apply the difference principle in the intergenerational context, other authors did, arriving at a high or even infinite value of ν_{cd} and therefore $\mathrm{CRI}_{\mathrm{cd}}$ (see e.g. Solow, 1974; d'Arge et al., 1982). If future generations are wealthier, *any* expenditure on mitigation will worsen the position of the least well-off generation, the present. According to the libertarian Nozick (1974, p. ix), "Individuals have rights, and there are things no person or group may do to them (without violating their rights)." Nozick therefore argues that no risk may ever be imposed on others without their express consent. With reference to such absolute rights as the right to be left unharmed in health or property, authors such as Sen (1982) and Spash (1993, 1994) have questioned the whole notion of discounting.

The problem, however, is that such views build on *ideal* moral theories rather than on the actual moral choices that societies have already made and institutionalised

in law, as well as in other ways, and that stipulate how contemporaries should treat one another. It is difficult to see how governments could endorse moral choices with respect to the treatment of future generations that conflict with the moral choices already endorsed by the same governments with respect to behaviour among contemporaries. For example, if all the institutionalised moral choices guiding society were based on utilitarian principles, governments could not found intergenerational justice on Rawls' principles. The very concept of justice requires governments to treat equal cases equally, which means that *if* a government decides to embrace intergenerational justice, it cannot just start from scratch and deem the social discount rate for climate damage an experimental playground for new moral views.

Once more, I emphasise that I claim neither that the moral choices guiding permitted behaviour among contemporaries are 'just' in a moral sense, nor that all societies have made the same moral choices. Intergenerational justice requires a government merely to treat future generations according to the moral choices currently prevailing for its contemporary citizens. As laws may differ from country to country and from era to era, one consequence is that intergenerational justice may, in principle, do so as well. This does not undermine practical and successful implementation of intergenerational justice, however. For example, climate policy is shaped partly in international climate negotiations, with negotiators hailing from countries with different institutionalised moral codes. From their respective negotiating positions, however, negotiators only have to treat future generations as moral equals with respect to the moral rules institutionalised within their own countries. In this way future generations are treated as moral equals even though the outcome of the negotiations may be founded on other principles. Furthermore, the fact that institutionalised moral rules change with time does not complicate the process of shaping intergenerational justice. The emancipation of women was not complicated by the fact that at the time of the emancipation debate the institutionalised moral rules applying to the male section of the population were not yet fixed (as indeed they never will be).

5. Is a Zero CRI_{cd} Contrary to People's Preferences?

In the previous section I argued that consistency from the angle of intergenerational justice would require consistency between the consumption rate of interest for climate damage and existing legal systems prescribing permitted behaviour among contemporaries, implying $CRI_{cd} = 0$. The question now is whether such a CRI_{cd} would conflict with people's preferences.

According to the principle of consumer sovereignty, individuals are the best judges of their own welfare and social policy should be based upon individuals' own preferences. The social discount rate should therefore reflect people's actual consumption rate of interest (see e.g. Bauer, 1957; Eckstein, 1957; Marglin, 1963; and more recently Olson and Baily, 1981). In this article I do not challenge the

principle of consumer sovereignty. However, I do disagree with the assumption commonly made, by many authors, with reference to the principle of consumer sovereignty, *viz.* that people's consumption rate of interest for climate damage (CRI_{cd}) is revealed through market behaviour (see e.g. Nordhaus, 1994; Pearce et al., 2003). If there were only one consumption rate of interest, i.e. if the consumption rate of interest were the same for changes in one's own future consumption and for changes in the consumption of future generations due to climate change, then CRI_{cd} would be close to the market interest rate *i*, as can be seen from formula (2). As I have argued, however, people may employ different consumption rates of interest for these two kinds of changes in future consumption. As there are no separate capital markets on which these different 'time preferences' can be expressed, there is consequently no way that market behaviour can be used to distinguish citizens' preferences regarding handling of damage to future generations from preferences regarding their own future consumption.

Others have argued that there is no reason to presume any difference between the consumption rate of interest for changes in one's own future consumption and for changes in the consumption of future generations due to climate change, by making a comparison with *intra*-generational or *spatial* discounting (see e.g. Schelling, 1995, 1999; Pearce et al., 2003). They have argued that comparison of the limited expenditures by developed countries on foreign aid with expenditures to improve domestic living conditions would clearly show that there is no basic difference between the consumption rate of interest for one's own future consumption and that for the consumption of someone else separated from us in time or space. Pearce et al., for example, argue that

> "the ethical principle that 'all men and women are equal' is not one that is practised anywhere in the world. If everyone was equal in an economic sense, for example, expenditure by rich countries on saving lives in poor countries would be higher than expenditure on saving the rich countries' 'own' lives. The extra (marginal) cost of life-saving in poor countries is very much lower than the extra cost of saving lives in rich countries. Yet the opposite is true . . ."

However, as I have argued in Section 2.2, one should distinguish (revealed) preferences regarding negative duties from (revealed) preferences regarding positive duties. While the willingness to help others, correlated with acknowledgement of positive duties, clearly diminishes the remoter people are from us, the willingness not to harm others, correlated with acknowledgement of negative duties, does not necessarily diminish the remoter people are from us (Kamm, 1999). In fact, as I have argued in Section 3, the duty to mitigate risk imposed on others is acknowledged in equal measure for the entire global population through commitments that have been institutionalised in national and international law. Since there is no direct correlation between the willingness to pay for aid and the willingness to pay to prevent harm, expenditure on development aid does not tell us much about people's

preferences concerning the prevention of damage to future generations for which we are responsible, i.e. CRI_{cd}.

Since people's CRI_{cd} is revealed neither by market behaviour nor by development aid budgets, governments find themselves obliged to make an explicit political choice with respect to CRI_{cd}, based on the preferences expressed by their citizens in democratic debate and through the democratic process. In many countries the majority of citizens have expressed their concern for the well-being of future generations via democratic debate. Likewise, most elected politicians have expressed such concerns en route to their election. Consequently, politicians did not come without a mandate when they signed up to the Rio Declaration on Environment and Development in 1992, and in particular Principle 3: "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations." In particular, the Parties to the United Nations Framework Convention on Climate Change (1992) have stated to be "determined to protect the climate system for present and future generations". In 1997, the general conference of UNESCO adopted the 'Declaration on the Responsibilities of the Present Generations Towards Future Generations', of which Article 5.2 states that "The present generations should ensure that future generations are not exposed to pollution which may endanger their health or their existence itself". Governments have indeed expressed this commitment to intergenerational justice at several key summits (see e.g. UNCHE, 1972; WCED, 1987; UNCED, 1992) and in national policy reports. Since there is no reason to assume that by expressing this commitment governments acted against the electoral will, there is no reason to assume that applying a CRI_{cd} equal to zero would be contrary to people's preferences and thus in conflict with the principle of consumer sovereignty.

6. The Social Discount Rate for Climate Damage

In the previous sections I have argued for CRI_{cd} equal to zero. With formula (5) the social discount rate for climate damage then becomes:

$$SDR_{cd} = \alpha \ MRRI \tag{6}$$

Let me clarify this formula with an example and a comparison to the shadow price of capital approach. Suppose that the marginal rate of return on private investment is 5%, that invested capital remains fully invested and that, of the returns on investment, a fraction is reinvested equal to society's marginal propensity to save (20%). Suppose, further, that one is considering an investment of $100 to prevent $300 of damage occurring 100 years from now. Such an investment would result in an infinite flow of alternative investment losses and therefore consumption losses covering not only the period between year 0 and 100 in which damage occurs, but also later years (Table I).

TABLE I

Consumption and alternative investment losses due to a $100.00 investment to prevent damage in a hundred years

	Investment in damage prevention	Alternative investment losses	Consumption losses (cumulative)	Prevented damage
Year 0	$100.00	$−20.00	$−80.00	
Year 1		$ −20.20	$ −80.80	
Year 2		$ −20.40	$ −81.61	
Year 3		$ −20.61	$ −82.42	
...		...	...	
Year 100		$ −54.10	$ −216.38	$ −300.00
...		...	...	

The shadow price of capital is obtained by summing the consumption losses due to investment in damage prevention discounted at the consumption rate of interest. The consumption rate of interest for consumption losses between year 0 and 100 due to investment in damage prevention is equal to CRI_{cd}: although the risk creator is not allowed to calculate to his own advantage by discounting damage to the risk bearer, neither is he obliged to put himself at a disadvantage by discounting consumption losses between year 0 and 100 due to investment in damage prevention. Therefore, these consumption losses are summed at a zero consumption rate of interest, resulting in a total of $ −216.38. *After* year 100, however, it is the risk bearer himself who will face any further consumption losses due to investment in damage prevention. Since the risk bearer can interchange consumption and investment, he will be indifferent to $54.10 of alternative investment losses in year 100 versus $54.10 of consumption losses in year 100. The $54.10 of alternative investment losses in year 100 is therefore counted as $54.10 of consumption losses in year 100. This gives the same result as applying a consumption rate of interest for consumption losses due to investment in damage prevention after year 100 equal to the marginal rate of return on investment. As a result, the shadow price of investing $100 to prevent damage occurring 100 years from now is $270.48 ($216.38 plus $54.10). Since this is less than the $300 prevented damage, reasonable care would require such an investment in mitigation. This is exactly the same conclusion that is obtained if the damage occurring 100 years from now is discounted at a social discount rate of α times MRRI (1%) and compared with present investment costs. The present value of the damage is then $110.91, which is more than $100.00 of investment. The present value of $270.48 in year 100 discounted at 1% is exactly $100.00. In other words, formula (6) is exact under the assumption of average saving behaviour and by attributing consumption losses due to investment in damage prevention after damage occurs to the risk bearer.

7. Conclusion

In this article I have argued that under current law neither geographic distance nor differences in wealth between risk creator and risk bearer play any part in establishing a standard of 'reasonable care'. The concept of intergenerational justice requires these same principles to be applied in the intergenerational context too, implying a zero consumption rate of interest for climate damage. Furthermore, it has been argued that such a consumption rate of interest does not conflict with the principle of consumer sovereignty. Assuming that the extent to which mitigation is at the expense of alternative investments is equal to society's marginal propensity to save, the social discount rate becomes society's marginal propensity to save times the long-term market rate of return on private investment. Although this article does not enter into the debate on long-term interest rates, it is anticipated that the social discount rate will then be around one per cent or a fraction of one per cent. One possible consequence for policy-makers is that the 'right' carbon tax may well exceed 100 Euro per tonne of carbon, compared with the figure of around 10 Euro per tonne currently being discussed on the basis of a social discount rate of 6% (see e.g. Eyre et al., 1999; Nordhaus and Boyer, 2000).

Acknowledgments

The Dutch Organization for Scientific Research (NWO) and the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM) funded this research. I thank Govert den Hartogh, Jeroen van den Bergh, Bob Brouwer, Edgar du Perron, Arnold Heertje, Nigel Harle and three anonymous reviewers for their valuable comments on the manuscript.

Notes

[1]Positive law sometimes even requires consumption losses to the risk bearer to be afforded a higher weight than consumption losses to the risk creator. In the United Kingdom the Law Lords were asked in 1949 to give a definitive ruling on the meaning of 'reasonably practicable'. Lord Justice Asquith (1949) ruled that "'Reasonably practicable' is a narrower term than 'physically possible' and seems to me to imply that a computation must be made by the owner in which the quantum of risk is placed on one scale and the sacrifice involved in measures necessary for averting the risk (whether in money, time or trouble) is placed in the other, and that if it be shown that there is a *gross disproportion* between them – the risk being insignificant in relation to the sacrifice – the defendants discharged the onus on them." (emphasis added).

[2]It should be noted that current law is incompatible not only with this 'growth discounting', but also with 'equity weighting', the intragenerational counterpart of growth discounting (see e.g. Fankhauser et al., 1997). If a higher per capita income of future generations is a motive for discounting future costs to them in cost-benefit analysis, then the lower per capita income of the inhabitants of developing countries is then a motive for assigning costs to them greater weight. As I have argued, however, legal regulation provides no grounds for applying growth discounting to damage to future generations.

Likewise, legal regulation provides no grounds for applying equity weighting to harm suffered by the populations of developing countries.

References

Abraham, K. S. and Jeffries, J. C. Jr.: 1989, 'Punitive damages and the rule of law: The role of defendant's wealth', *J. Legal Stud.* **18**(2), 415–425.

Arlen, J.: 1992, 'Should defendants' wealth matter?', *J. Legal Stud.* **21**(2) 413–429.

Arlen, J.: 2000, 'Tort damages', in Bouckaert B. and De Geest, G. (eds.), *Encyclopedia of Law & Economics* **2**, Edward Elgar, Cheltenham.

Arrow, K. J. and Kurz, M.: 1970, *Public Investment, the Rate of Return, and Optimal Fiscal Policy*, Johns Hopkins University Press, Baltimore, MD, U.S.A.

Arrow, K. J., Cline, W. R., Mäler, K. G., Squitieri, R., and Stiglitz, J. E.: 1996, 'Intertemporal equity discounting, and economic efficiency', in Bruce, J. P., Lee, H., and Haites, E. F. (eds.), *Climate Change 1995 – Economic and Social Dimensions of Climate Change*, Cambridge University Press, Cambridge, pp. 125–144.

Asquith, Lord Justice: 1949, 'Edwards v. National Coal Board', *All England Law Reports* **1**, 747.

Azar, C.: 1998, 'Are optimal CO_2 emissions really optimal?', *Environ. Resour. Econ.* **11**(3–4), 301–315.

Baumol, W. J.: 1952, *Welfare Economics and the Theory of the State*, Harvard University Press, Cambridge, MA.

Bauer, P. T.: 1957, *Economic Analysis and Policy in Underdeveloped Countries*, Duke University Press, Durham, NC.

Bradford, D. F.: 1975, 'Constraints on government investment opportunities and the choice of discount rate', *American Economic Review* **65**(5), 887–899.

Cline, W. R.: 1992, *The Economics of Global Warming*, Institute for International Economics, Washington, DC.

D'Arge, R. C., Schulze, W. D., and Brookshire, D. S.: 1982, 'Carbon dioxide and intergenerational choice', *American Economic Review* **72**(2), 251–256.

De George, R. T.: 1979, 'The environment, rights and future generations', in Goodpaster, K. E. and Sayre, K. M. (eds.), *Ethics and Problems of the 21st Century*, University of Notre Dame Press, Notre Dame, pp. 93–105.

Dobb, M.: 1960, *An Essay on Economic Growth and Planning*, Routledge & Kegan Paul, London, p. 19.

Eckstein, O.: 1957, 'Investment criteria for economic development and the theory of intertemporal welfare economics', *Quarterly Journal of Economics* **71**(1), 56–85.

Eckstein, O.: 1958, *Water Resource Development: The Economics of Project Evaluation*, Harvard University Press, Cambridge, MA.

Eyre, N., Downing, T., Hoekstra, R., and Rennings, K.: 1999, *Externalities of Energy, Volume 8: Global Warming Damages*, Office for Official Publications of the European Commission, Luxembourg.

EPA (United States Environmental Protection Agency): 2000, *Guidelines for Preparing Economic Analysis*, Washington D.C.

Fankhauser, S. and Tol, R. S. J.: 1996, 'Climate change costs – recent advancements in the economic assessment', *Energy Policy* **24**(7), 665–673.

Fankhauser, S., Tol, R. S. J., and Pearce, D. W.: 1997, 'The aggregation of climate change damages: A welfare theoretic approach', *Environ. Resour. Econ.* **10**(3), 249–266.

Feinberg, J.: 1973, *Social Philosophy*, Englewood Cliffs, NJ.

Hand, Judge L.: 1947, *United States v. Carroll Towing Co.*, 159 F.2d 169 (2d Cir. 1947).

Harberger, A. C.: 1972, *Project Evaluation: Collected Papers*, The University of Chicago Press, Chicago.

Haveman, R. H.: 1969, 'The opportunity cost of displaced private spending and the social discount rate', *Water Resources Research* **5**(5), 947–957.

HM Treasury: 2003, *The Green Book; Appraisal and Evaluation in Central Government*, HM Treasury, London.

Howarth, R. B.: 2003, 'Discounting and uncertainty in climate change policy analysis', *Land Economics* **79**(3), 369–381.

Kamm, F. M.: 2000, 'Does distance matter morally to the duty to rescue?', *Law and Philosophy* **19**(6), 655–681.

Kaplow, L. and Shavell, S.: 1994, 'Why the legal system is less efficient than the income tax in redistributing income', *J. Legal Stud.* **23**(2), 667–681.

Koopmans, T. C.: 1960, 'Stationary ordinal utility and impatience', *Econometrica* **28**(2), 287–309.

Krutilla, J. V. and Eckstein, O.: 1958, *Multiple Purpose River Development*, Johns Hopkins University Press, Baltimore, MD, U.S.A.

Lagerspetz, E.: 1999, 'Rationality and politics in long-term decisions', *Biodiversity and Conservation* **8**(1), 149–164.

Lind, R. C.: 1982, 'A primer on the major issues relating to the discount rate for evaluating national energy options', in Lind, R. C. et al. (eds.), *Discounting for Time and Risk in Energy Policy*, Resources for the Future, Washington, D.C.

Marglin, S. A.: 1963, 'The social rate of discount and the optimal rate of investment', *Quarterly Journal of Economics* **77**(1), 95–111.

Marshall, A.: 1890, *Principles of Economics*, Macmillan and Co., Ltd., London.

Mendelsohn, R. and Neumann, J. (ed.): 1999, *The Impacts of Climate Change on the US Economy*, Cambridge University Press, Cambridge.

Miceli, T. J. and Segerson, K.: 1995, 'Defining efficient care: The role of income distribution', *Journal of Legal Studies* **24**(1), 189–208.

Newell, R. G. and Pizer, W. A.: 2003, 'Discounting the distant future: how much do uncertain rates increase valuations?', *Journal of Environmental Economics and Management* **46**(1), 52–71.

Newell, R. G. and Pizer, W. A.: 2004, 'Uncertain discount rates in climate policy', *Energy Policy* **32**(4), 519–529.

Nordhaus, W. D.: 1994, *Managing the Global Commons*, MIT Press, Cambridge, MA.

Nordhaus, W. D.: 1997, 'Discounting in economics and climate change: An editorial comment', *Clim. Change* **37**(2), 315–328.

Nordhaus, W. D. and Boyer, J.: 2000, *Warming the World: Economic Models of Global Warming*, MIT Press, Cambridge, MA.

Nozick, R.: 1974, *Anarchy, State, and Utopia*, Basic Books, New York.

Ogus, A. I.: 1997, 'Risk management and 'rational' social regulation', in Baldwin, R. (ed.), *Law and Uncertainty: Risks and Legal Processes*, Kluwer Law International, The Hague, pp. 139–153.

Olsen, M. and Bailey, M.: 1981, 'Positive time preference', *Journal of Political Economy* **89**(1), 1–25.

OMB (Office on Management and Budget): 1992, *Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, http://www.whitehouse.gov/omb/circulars/a094/a094.html

Parfit, D.: 1984, *Reasons and Persons*, Oxford University Press, Oxford.

Pearce, D. and Turner, R. K.: 1990, *Economics of Natural Resources and the Environment*, Harvester Wheatsheaf, Hemel Hempstead.

Pearce, D., Groom, B., Hepburn, C., and Koundouri, P.: 2003, 'Valuing the future: Recent advances in social discounting', *World Economics* **4**(2), 121–141.

Pogge, T.: 2002, *World Poverty and Human Rights*, Polity Press, Cambridge.

Portney, P. R. and Weyant, J. P. (eds.): 1999, *Discounting and Intergenerational Equity*, Johns Hopkins University Press, Baltimore.

Rabl, A.: 1996, 'Discounting of long term costs: What would future generations prefer us to do?' *Ecological Economics* **17**(3), 137–145.

Ramsey, F. P.: 1928, 'A mathematical theory of saving', *Economic Journal* **38**(152), 543–59.

Rawls, J.: 1972, *A Theory of Justice*, Oxford University Press, Oxford.

Revesz, R. L.: 1999, 'Environmental regulation, cost-benefit analysis, and the discounting of human lives', *Columbia Law Review* **99**(4), 941–1018.

Sandmo, A. and Dreze, J. H.: 1971, 'Discount rates for public investments in closed and open economies', *Economica* **38**(152), 395–412.

Schelling, T. C.: 1995, 'Intergenerational discounting', *Energy Policy* **23** (4/5), 395–401.

Schelling, T. C.: 1999, 'Intergenerational discounting', in: Portney P. R. and Weyant J. C. (eds.), *Discounting and Intergenerational Equity*, Resources for the Future Washington, DC, pp. 99–101.

Schindler, D.: 1921, 'The administration of justice in the Swiss Federal Court in intercantonal disputes', *American Journal of International Law* **15**(2), 149–188.

Sen, A. K.: 1982, 'Approaches to the choice of discount rates for social benefit-cost analysis', in Lind, R. C. et al. (eds.), *Discounting for Time and Risk in Energy Policy*, Resources for the Future, Baltimore, MD: Johns Hopkins University Press, pp. 325–353.

Shrader-Frechette, K. S.: 1998, 'Risk, ethics, and discounting future generations', in Mosleh A. and Bari, R. A. (eds.), *Probabilistic Safety Assessment and Management, Proceedings of the 4th International Conference on Probabilistic Safety Assessment and Management (PSAM 4)*, vol. 4, Springer-Verlag, London, pp. 2553–2358.

Shrader-Frechette, K. S. and Persson, L.: 2001, *Ethical Problems in Radiation Protection,* Stockholm, Sweden: The Swedish Radiation Protection Authority. SSI-Report 2001:11.

Solow, R. M.: 1974, 'Intergenerational equity and exhaustible resources', *Review of Economic Studies* **41** (Symposium on the Economics of Exhaustible Resources), 29–45.

Spash, C. L.: 1993, 'Economics, ethics, and long-term environmental damages', *Environmental Ethics* **15**(2), 117–132.

Spash, C. L.: 1994, 'Double CO_2 and beyond: Benefits, costs and compensation', *Ecological Economics* **10**(1), 27–36.

Trail Smelter Arbitral Tribunal: 1941, 'Decision', *The American Journal of International Law* **35**(4), 684–736.

Tullock, G.: 1964, 'The social rate of discount and the optimal rate of investment: Comment', *Quarterly Journal of Economics* **78**(2), 331–336.

UNCHE: 1972, *Stockholm Declaration of the United Nations Conference on the Human Environment*, June 16, 1972, U.N. Doc.A/Conf.48/14/Rev.1.

UNCED: 1992, *Rio Declaration on Environment and Development and Agenda 21*. The United Nations Conference on Environment and Development. Rio de Janeiro.

WCED (World Commission on Environment and Development): 1987, *Our Common Future: The Brundtland Report*, Oxford University Press, New York.

Weitzman, M. L.: 1998, 'Why the far distant future should be discounted at its lowest possible rate', *Journal of Environmental Economics and Management* **36**(3), 201–208.

Weitzman, M. L.: 2001, 'Gamma discounting', *The American Economic Review* **91**(1), 260–271.

(Received 21 May 2004; in revised form 13 September 2005)