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**Arguing about climate change : judging the handling of climate risk to future generations by comparison to the general standards of conduct in the case of risk to contemporaries**

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# Chapter 5: How reasonable man discounts climate damage

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## Abstract

The social rate of time preference to be used in cost-benefit analysis of climate policy differs from the social rate of time preference to be used for policy issues which do not involve the prevention of risk of harm to future generations. The reason is that people weigh changes in other people's consumption differently, depending on whether or not a violation of rights is at stake. These different preferences are reflected in the standard of the 'reasonable man' from common law. There is no reason why these different preferences should not hold equally in the intergenerational context. If applied to the issue of climate policy, the reasonable man standard implies a zero social rate of time preference. The social discount rate for climate damage is about half a percent, the product of a twenty percent savings rate and a two to three percent risk-free rate of return on alternative investments.

## 1. Introduction

The *Stern Review on the Economics of Climate Change* (Stern, 2006) has refuelled the already hot debate on the social rate of time preference to be used in cost-benefit analysis of climate policy. The social rate of time preference determines how to weigh the benefits of climate policy, i.e. the climate-change-related damage prevented decades hence, against the consumption we would presently lose by incurring expenses on climate damage prevention. In his Review, Stern describes the common point of departure of standard welfare economics:

“The ethical framework of standard welfare economics looks first only at the consequences of actions (an approach often described as ‘consequentialism’) and then assesses consequences in terms of impacts on ‘utility’ (an approach often described as ‘welfarism’ ...). This standard welfare-economic approach has no room, for example, for ethical dimensions concerning the processes by which outcomes are reached. Some different notions of ethics, including those based on concepts of rights, justice and freedoms, do consider process.”

With respect to the social rate of time preference, welfarism implies the point of view that there is but one social rate of time preference, to be applied consistently across all policy issues. This rate may be time-

dependent (Thaler 1981; Frederick, Loewenstein, and O'Donoghue 2002), but at any given moment it is assumed to be the same for different changes in welfare. Welfarism assumes that it makes no difference whether or not the future change in welfare results from any violation of rights. Although Stern's particular quantitative choice of the social rate of time preference has been amply criticised (Beckerman and Hepburn 2007; Dasgupta 2007; Nordhaus 2006; Weitzman 2007), the underlying framework of welfarism still remains virtually uncontested (see also Dasgupta 2007 and for a notable exception Sen 1982).

However, while the welfarism perspective may be justified for certain policy issues, in the case of climate change this is not the case. Society does not perceive climate policy as a mere redistribution of our income to future generations (Schelling 1995) or as a gift to them (Lind 1999), but as a matter of justice – and when justice is at stake, welfarism contradicts people's everyday behaviour and preferences. In the real world people are not indifferent to the 'ethical dimensions concerning the processes by which outcomes are reached'. If economics ought to be based on the principle that preferences count (Pearce et al. 2003) and that societies should not be ruled by 'elites and philosopher-kings' (Beckerman and Hepburn, 2007), then economists should not ignore these preferences.

The purpose of this chapter is therefore first to show that people do indeed weigh changes in other people's consumption differently, depending on whether or not a violation of rights is at stake. In fact, these different preferences are already reflected in the standard of the 'reasonable man' from common law. In section 3, I argue that there is no reason why these different preferences should not hold equally in the intergenerational context. In section 4, I show how 'reasonable man' would discount climate damage. In section 5, I show that by assuming different social rates of time preference for different policy issues, the so-called opposition between the prescriptionist and descriptionist view can be resolved. In section 6, I discuss the extent to which expenditure on climate risk mitigation displaces alternative investment and, in section 7, how to estimate the rate of return that might be achieved on such alternative investment. In section 8, finally, I discuss the results. This chapter extends the work in the previous chapter (Davidson, 2006), first by offering new argumentation for the application of the reasonable man standard and second by offering a quantitative analysis in addition to the qualitative analysis in the previous chapter.

## **2. Spatial discounting and reasonable man**

Not without reason, the social rate of time preference is called a *preference*. It expresses society's preference as to how to weigh changes in present consumption against changes in future consumption. Since it is a preference,

it may depend on the issue at hand. As there is no fundamental difference between temporal discounting and *spatial* discounting, I first show that societies do indeed hold different preferences with regard to changes in welfare affecting contemporaries rather than future generations.

According to the standard welfare economic point of view, people have two basic reasons for discounting future changes in consumption relative to present changes (Ramsey 1928). First, people simply care less about remote events. Second, the wealthier one is, the less changes in consumption matter. In the world around us such discounting can indeed be observed in spatial terms, too. Thus, people generally attach less value to changes in other people's utility compared with their own, with that value declining ever further the more (empathically) remote those others are. We spend most on our own well-being, less on the well-being of our fellow countrymen via social security payments, and far less on the well-being of people abroad via development aid. If we are willing to spend money on the well-being of others, we are certainly less inclined to improve the well-being of the well-to-do than that of the poor.

However, this picture of reality only holds as long as there are no rights at stake. In practice, the cited behaviour is constrained by one's respect for other people's rights to bodily integrity and personal property. Although I may prefer winning the lottery rather than you, this does not imply a preference for stealing your property if you happen to win. Likewise, the fact that I care less about your gains from my activities than my gains does not imply indifference on my part if my activities happen to harm your property or health. Although I have no duty to benefit you, I have a duty not to harm you. Giving someone a hundred dollars and inflicting a hundred dollars of harm are not the same thing, simply with an opposite sign. From the perspective of welfarism they are, however.

It is not merely the case that people reveal a preference for rights to be respected and a willingness to respect the rights of others; these preferences have also been formalized in law. In our society, everyone has a legal duty not to cause injury to others, whether negligently or with intent. Risk of harm to others can never be avoided entirely, however. Therefore, common law requires us to take the care that a *reasonable man* would exercise under the circumstances. According to the Second Restatement of Torts (§ 291) of U.S. common law, for example:

“Where an act is one which a reasonable man would recognize as involving risk of harm to another, the risk is unreasonable and the act is negligent if the risk is of such magnitude as to outweigh what the law regards as the utility of the act or of the particular manner in which it is done.”

People do not only have a legal duty to exercise the care of a reasonable man when their acts involve the risk of harm to fellow-countrymen; international treaties also oblige us to take reasonable care when our acts involve the risk

of harm to people living abroad, as in the case of transboundary air pollution (see e.g. UNCHE 1972; UNCED 1992).

Since the standard of reasonable man is highly relevant for the issue of intergenerational justice, I discuss this standard in more detail. Please note that I have no intention to advocate a particularly male view on the subject, but wish to stay close to common legal parlance. The most common interpretation of reasonableness was introduced by Judge Learned Hand in the famous *Carroll Towing* case (Hand 1947; see also Posner 1978, 2002; Landes and Posner 1987):

“[T]he owner's duty, as in other similar situations, to provide against resulting injuries is a function of three variables: (1) The probability that she will break away; (2) the gravity of the resulting injury, if she does; (3) the burden of adequate precautions. Possibly it serves to bring this notion into relief to state it in algebraic terms: if the probability be called P; the injury, L; and the burden, B; liability depends upon whether B is less than L multiplied by P: i.e., whether B less than PL.”

In other words, an act is considered reasonable if the resulting benefits outweigh the risk of harm to another person, a view which is reflected for example in the First, Second and draft Third Restatement of Torts of U.S. common law (Wright 2002). If damage is to occur, the reasonable man is entitled to demonstrate to the victim that the benefits outweigh the damage. It should be noted that the standard of reasonable care does not necessarily require compensation for damage. In the case of negligence liability, one is only responsible for compensatory damages if one has failed to take reasonable care.

The Hand interpretation of reasonableness is not undisputed, though (Wright 2002; Gilles 2001; Zipursky 2007). Some have remarked that there is generally more to the determination of negligence or reasonableness than the weighing of benefits and risk of harm, or that not all the relevant factors can be encompassed by a single (economic) metric. However, since discounting involves no more than the weighing of costs and benefits, this criticism need not concern us here. A second criticism is that the Hand formula is not stringent enough. Wright (1995, 2002) offers an example of a possible criticism: “It is not properly respectful of the equal dignity and autonomy of others, and hence not just, for you to impose substantial unaccepted risks of injury or loss upon them merely for your own personal benefit, even if your gain will exceed their loss.” This might explain why English law sometimes attaches greater weight to the injury. When 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).

Since the Hand formula offers the most common interpretation of the reasonable man standard and this standard, as I shall argue, would already qualify most argumentation in the present discounting debate as *negligent*, I shall interpret the reasonable man standard as requiring an act to result in benefits outweighing the risk of harm to another person. It should be borne in mind, though, that more stringent interpretations are conceivable.

There are two features of the reasonable man standard that are of particular importance for the discounting issue. Although the standard of ‘reasonable care’ is open to interpretation, no legal interpretation is conceivable in which the risk creator explicitly characterises losses by the risk bearer as less important on the grounds that the risk bearer is wealthier than the risk creator, or (empathically) remote (Arlen 1992, 2000). Although Marshall (1890) 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", no judge or court would see this as a justification for the less wealthy to harm the better off. If the Mexican government, for example, were to perform a cost-benefit analysis of a power plant to be built near the border with the United States, it would not be permitted to discount any dollar of harm experienced by U.S. citizens, for example due to sulphur deposits, to account for the fact that U.S. citizens are on average five times wealthier than Mexican citizens or to account for the fact that the emotional ties between fellow Mexicans are generally stronger than those between Mexicans and U.S. citizens. Even if governments occasionally follow these lines of reasoning *off the record*, it is inconceivable that such reasoning would be written down and justified in public policy reports. Furthermore, such conduct would violate international law.

In conclusion, while people generally attach less weight to changes in consumption if these changes are experienced by people who are wealthier or (empathically) remote, reasonable man applies a zero *consumption rate of interest* if he recognizes that his acts involve risk of harm to others. This is not just one theoretical moral position among many, but a social preference revealed through the establishment of law and accepted standards of conduct. It is therefore to be concluded that societies do indeed hold different preferences as to how to weigh changes in other people’s welfare, depending on whether or not rights are at stake.

### 3. Intergenerational justice

If the prevailing social preference as to how to value changes in other people's welfare depends on whether or not rights are at stake, why should this then differ if these others are not contemporaries, but future generations? What could justify governments handling trans-national air pollution according to different moral rules than trans-generational air pollution (see also Parfit, 1983)? Certainly, we have as yet no well-defined legal duties towards future generations. Some might even question whether our present acts really involve any risk of harm to them (see for a discussion: Davidson, 2008). Yet, it is a political reality that most governments have already recognized that our present acts involve the risk of harm to future generations, for example through climatic change (UNFCCC 1992). Moreover, most governments have expressed their commitment to intergenerational justice (UNFCCC 1992; UNESCO 1997; UNEP 1997; UK Government 1999). Although intergenerational justice is difficult to define, 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, this requirement means that every person 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 (Rawls 1972; Shrader-Frechette and Persson 2001). Therefore, a relevant question for any government taking its commitments to intergenerational justice seriously is how to handle the risk of damage future generations experience due to our present acts through the eyes of the 'reasonable man' from common law.<sup>1</sup>

It may be argued that the reasonable man standard involves assessments of damages that differ in their context from the problem of climate change, in which the core issue is the potential for intergenerational damages experienced by persons largely as yet unborn. The point, however, is that the differences in context are *morally irrelevant*. In former times, the law was not applied equally to foreigners, coloured people and women. For sure, at the time the context in which the law was applied also varied: application to coloured people, for example, too place in a different context from its 'normal' application, i.e. to white people. However, since the differences between white and coloured people were morally irrelevant, the formal requirement of justice required the law to be applicable to coloured as well as white people. There was no discussion possible about other moral views on how to treat coloured people except by simply extending law to encompass coloured people as well. Therefore, the application of the

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<sup>1</sup> Please note that this interpretation of intergenerational justice is explicitly linked to actual law in contrast to various interpretations of intergenerational justice based upon principles of distributional fairness (see e.g. Howarth 1997).

reasonable man standard in the intergenerational context is not just one moral point of view among many. *Even* if one were to disagree with the reasonable man standard from common law, intergenerational justice cannot mean anything but the application of present law to future generations, until such time as the reasonable man standard itself, as applied to contemporaries, is changed.<sup>2</sup>

To my knowledge, there is no government or government statement which has expressed the point of view that future generations differ from present generations in any morally relevant respect that might justify different treatment, i.e. that norms regarding the handling of risk to others should not apply equally to future generations. On the contrary, in public debates and policy reports a willingness is generally expressed to treat future generations in accordance with justice. If economics are to be based on the principle that preferences count and that societies should not be ruled by ‘elites and philosopher-kings’, then it is highly relevant that most people *do* consider physical injury or personal loss experienced by future generations due to man-made climate change to be wrongful harms, for which the present generations are morally accountable.

Finally, it may be argued that society’s support for intergenerational justice is only a weak ‘stated preference’ that will not be confirmed as a ‘revealed preference’ once governments actually implement climate policy on the basis of the reasonable man standard. This conclusion is premature, however. Economists generally downplay citizens’ support of intergenerational justice on the basis of a comparison with Western budgets for development aid, which are only a tiny fraction of the budgets spent locally on health care, education, unemployment benefits, et cetera, even though an Euro spent in a developing country will most likely be better ‘value for money’ (Pearce et al. 2003). As argued earlier, though, people’s willingness to improve the general well-being of others has little to do with their willingness to respect the right of others to be left unharmed. While our willingness to help others clearly diminishes the more remote those others are, this is not necessarily the case when it comes to our willingness not to harm others. This distinction between helping and not harming is reflected in common law: although the reasonable man has a duty not to cause injury to others, he may exercise self-interest and is not required to donate his money to the poor, for example. Therefore, 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. So all we know about the willingness of the citizenry to prevent harm to future generations is what they express directly, through the political process, and this does in fact

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<sup>2</sup> On the basis of an utilitarian, consequentialistic moral view Parfit (1983), for example, argues that discounting is morally allowed to account for the fact that future generations may be wealthier. However, the point is that as long as this moral view is not reflected in common law it cannot be a basis for intergenerational justice.

indicate such a willingness. To confront society with an ‘optimal’ climate policy in which economists already anticipate society’s presumed unwillingness to protect future generations against harm is to put the cart before the horse.

#### **4. How reasonable man discounts climate damage**

What might the reasonable man standard imply in the case of climate damage, where the initial act and the damage are separated by many decades? The answer to this question is complicated by the fact that expenditure on climate change mitigation is not only at the expense of present consumption, but at the expense of alternative investments as well, reducing the opportunities for increased future consumption. Owing to reinvestment, expenditure on climate risk mitigation may in fact be at the expense of a consumption stream extending infinitely into the future. How then to compare postulated climate damage with this infinite consumption stream that would be lost if expenses are incurred to prevent climate damage? Here, too, reasonable man should be able to justify his acts to the victim, although this will generally be in thought only, for in all probability our reasonable man is already deceased by the time the damage has occurred. The latter fact is morally irrelevant, however. What benefits of his actions could justify the ensuing damage? First, he could point to the consumption that had resulted from not refraining from the act he performed or not reducing its risk. This consumption includes not only the consumption at the time of the act, but also that occurring between then and the moment of damage, ensuing from alternative investment of the money that would otherwise have been spent on risk prevention. Second, he could point to the investments made from the moment of his act up to the moment of damage. That investment sum would be available to the victim and could be diverted to consumption as well. If the sum of these two benefits – the consumption *before* the moment of damage and the investment still available *at* the moment of damage – outweighs the damage, reasonable man would not have been negligent. The benefits of his acts would then outweigh the costs and he would have taken reasonable care.

By adding the investment sum available to the victim to the consumption before the moment of damage, we can neglect the consumption stream extending beyond the moment of damage. It is up to the victim how to divert the investment sum. If one prefers, however, one can also ignore the investment sum, and instead add the consumption stream extending beyond the moment of damage discounted against the consumption rate of interest for changes in one’s *own* consumption, since this stream is viewed from the point of view of the victim. Under the assumption that the interest rate for changes in one’s own consumption is closely related to the (risk-

free) rate of return on investment, this will give the same result as adding the investment sum available at the moment of damage.

Table 1 clarifies this approach by means of a numerical example. In this example, I take an advance on two assumptions which I shall substantiate in later sections. First, I assume a marginal propensity to save of 20% (section 6); second I assume a two and a half percent (risk-free) rate of return on investment (section 7). That means that money saved by *not* investing in damage prevention is consumed for 80% and alternatively invested for 20%. Furthermore, I assume that invested capital remains fully invested and that the same 20% of the returns on investment is reinvested. Imagine then sixty-one dollars are spent today to prevent one hundred dollars of climate harm in a hundred years' time. Would this expenditure still be *reasonable*? If sixty-one dollars are spent today on climate risk mitigation, we may expect – under the given assumptions – the loss of eighty dollars of consumption between today and the moment of harm, and the loss of twenty dollars of alternative investments at the moment of harm. This amount exactly balances the hundred dollars of climate damage. Therefore, the conclusion is that reasonable man would prevent a hundred dollars of climate damage in a hundred years time if it costs less than sixty-one dollars today.

Table 1 Consumption and alternative investment losses due to a \$ 60.73 investment to prevent damage in a hundred years' time.

	Investment in damage prevention	Alternative investment losses	Consumption losses (cumulative)	Prevented damage
Year 0	\$ - 60.73	\$ - 12.15	\$ - 48.58	
Year 1		\$ - 12.21	\$ - 48.83	
Year 2		\$ - 12.27	\$ - 49.07	
Year 3		\$ - 12.33	\$ - 49.32	
...		...	...	
Year 100		\$ - 20.00	\$ - 80.00	\$ 100.00

Basically, this calculation follows the shadow price of capital approach, in which future consumption flows are discounted against the consumption rate of interest (Eckstein 1958; Arrow and Kurz 1970; Bradford 1975; Lind 1982). The main difference with the common application, is a zero consumption rate of interest to consumption losses due to climate change and consumption (losses) due to alternative investments before the moment of damage.

Instead of using this shadow price of capital approach, one can also directly compare the climate damage against the present investment by means of the social discount rate instead of the consumption rate of interest. The social discount rate can be approximated by the weighted average of the

marginal rate of return on investment and the consumption rate of interest, where the weight factors are given by the marginal propensities to save and consume, respectively (Krutilla and Eckstein 1958; Haveman 1969; Sandmo and Dreze 1971; Harberger 1972). In the numerical example, where the marginal rate of return on investment is 2.5% and the marginal propensity to save is 20%, the social discount rate becomes 0.5%. And indeed, if a hundred dollars of climate damage in a hundred years time is discounted against a social discount rate of 0.5%, the same sixty-one dollars results as in the example.

In this numerical example, the climate damage is taken to occur at a single moment in time. Of course, in reality climate change is not such a 'one-off event'. However, the fact that climate damage extends over many decades or centuries does not alter the approach. Any stream of consumption losses due to climate change damage can be discounted by means of the social discount rate against present expenditure on damage prevention.

## 5. Two opposing views

Because of the assumption of a single social rate of time preference whatever the processes by which outcomes are reached, there has been an apparently unbridgeable gap between two opposing positions in the discount debate. Arrow et al. (1996) have labelled these positions the 'prescriptionist view', such as Stern's view according to which there is moral reason to 'treat the welfare of future generations on a par with our own' (Stern 2006) and the 'descriptionist view' according to which the social rate of time preference should reflect observed savings behaviour (see e.g. Weitzman 2007). The gap results, however, from the all-or-nothing moral choice welfarism commands: either *impersonal* welfarism, as advocated by Stern, or an 'agent-relative ethics' (Beckerman and Hepburn 2007; Arrow 1995, 1999), according to which we are justified to care less about the emphatically remote. The moral point of view of impersonal welfarism, as expressed in classical utilitarianism, has been criticized by moral philosophers as being too demanding and alienating from our personal projects and commitments (Smart and Williams 1973). Certainly, such a self-sacrificing and self-denying attitude is rarely found in this world and thus hardly corresponds to public preferences. An agent-relative welfarism conflicts just as much with moral theory and public preferences, however, for it neglects rights. The gap can be bridged, though, if welfarism is abandoned and it is acknowledged that the social rate of time preference may depend on whether or not rights are at stake.<sup>3</sup> When rights are *not* at stake, as in the case of present

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<sup>3</sup> Not accidentally Weitzman (1998) made his observation that "to think about the distant future in terms of standard discounting is to have an uneasy intuitive feeling that something is wrong, somewhere" in the context of "global climate change, radioactive

investments in transport or communications technology, there is no decisive moral reason to apply a lower social rate of time preference than observed in savings behaviour. When rights are at stake, though, there is good reason to apply a zero social rate of time preference. The latter rate does not conflict with observed savings behaviour, however, since savings behaviour has nothing to do with preferences regarding how people wish to deal with harm to future generations. Savings behaviour simply expresses how people weigh present and future changes in their *own* consumption. Preferences regarding intergenerational justice are expressed through the political process. The application of a zero social rate of time preference for future harm does not therefore imply that the present generations should save more for the future, since this rate does not relate to general investments. There is no general duty to make future generations wealthier.

Some argue, however, that the social rate of time preference is simply irrelevant, since future changes in consumption should always be discounted against the marginal rate of return on investment. After all, it is argued, if the future is discounted at a rate *lower* than the marginal rate of return on investment, then alternative investments are available which offer future generations a higher rate of return than the investment in climate change mitigation (Nordhaus 1997, 2006; Birdsall and Steer 1993). From the reasonable man perspective this approach will not do, though, for something is promised that cannot reasonably be delivered. On the one hand, we know that such a full, continuous (re)investment process is not an actual alternative. In practice, only a small fraction of society's expenditures on climate policy is at the expense of alternative investments, with the lion's share at the expense of present consumption (for quantitative estimates, see the next section). On the other hand, even if society were to immediately establish a dedicated investment fund from which to compensate future climate victims, it is highly doubtful whether such a fund would survive until the moment of climate damage (Lind 1995; Arrow et al. 1996; Cline 1999). Since, as Cline states (1999: 134), history gives us reasonable "fear that in the interim some populist administration will loot the fund", the idea that the present generations could *potentially* compensate future generations becomes unrealistic and baseless. If at some time in the future, therefore, we are called on to justify our present acts, we simply know we will be unable to demonstrate the benefits resulting from those acts that are supposed to

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waste disposal, loss of biodiversity, thinning of stratospheric ozone, groundwater pollution, [and] minerals depletion". These are precisely the kind of issues where people have an intuitive feeling that our present acts involve the risk of harm to future generations. In such cases, people also have an intuitive feeling we are not treating these risks with the same reasonable care we expect in the case of risk to our contemporary fellowmen. If, on the other hand, the examples involved future benefits resulting from increased present investments in communication or transport technologies, few people would share the same 'uneasy intuitive feeling' about discounting.

outweigh the future damage. Consequently, the Kaldor-Hicks compensation test will not be passed. Since the choice between two options – damage mitigation or not – should not depend on a third option that is in practice unavailable (Hammit and Harvey 2000), it is unreasonable to assume such a scenario in determining the reasonableness of our present acts. In other words, reasonable man does not compare future climate damage with an unrealistic, wishful-thinking scenario, but with a reasonable estimate of what will actually happen to consumption and investment as a result of his present acts.

## **6. Consumption and investment shares**

How to make a reasonable estimate of the fractions of expenditure on climate risk mitigation that are at the expense of consumption and alternative investment? Of course, these fractions depend on the kind of government action involved (Lind 1990). As a point of departure, however, I shall assume the government taking action to urge society to reduce greenhouse gas emissions, rather than the government itself making investments. One could think of direct regulation, such as the prescription of specific technologies, or generic policy instruments, such as introduction of a regulatory carbon tax or a system of tradable carbon rights. Even given this demarcation, there has been much debate about the displacement of consumption and investment. Some have argued that environmental regulation might not displace any private investment at all, for example Kolb and Scheraga (1990, see also Lind 1990):

“In competitive markets, the costs of environmental controls can be fully passed through to consumers in the long run, just as are other capital and operating costs. Product prices would increase by an amount reflecting the marginal rate of return on investment, the expected lifetime of the pollution controls, and any operating costs. The capital that was initially displaced would be returned to the economy as the firm recovers its costs over time. Further, it is reasonable to assume that consumers’ savings rates out of disposable income would not be affected by the regulation (i.e., they are fixed). Thus, the increased amount paid for products due to the imposition of environmental controls would come from reductions in other consumption, not from reductions in savings.”

This last assumption is unlikely, however, given the empirical fact of society's non-zero marginal propensity to save. In other words, if people have less disposable income, they reduce not only their consumption, but also their savings. Empirical estimates of the marginal propensity to save are a difficult matter, however, and a wide range of results is available (Souleles 1999, 2002; Dynan, Skinner, and Zeldes 2004). Furthermore, empirical data

on the marginal propensity to save out of disposable income is strongly influenced by fluctuations in the real value of assets. In the United States, for example, since the 90s the marginal propensity to save out of disposable income has been much lower than the overall savings rate (U.S. Census Bureau 2006), because the large increase in the real value of assets reduced the necessity to save (Hall and Mishkin 1982; Dynan and Maki 2001). If the increase in savings due to rising values of equities and real estate is included, the marginal propensity to save is much higher. Therefore, in cost-benefit analysis it is ‘common procedure’ (Pearce and Ulph 1999) to use the ratio of gross national investment to Gross National Product as an estimate of the share of expenditure on environmental investments from displaced alternative investment. It should be noted, however, that although a *marginal* propensity to save and invest is required, the most reliable data available concern the *average* ratio of gross national investment to Gross National Product. Cline, for example, uses this approach (1992: 237):

“If a carbon tax is used to discourage emissions, for example, the tax revenue comes out of the general economy. Similarly, if a quota limit is set on emissions, and less efficient means of production must be substituted for fossil fuels, the resulting reduction in production comes from the economy at large. In either case, the sourcing of the resource cost of the policy will reflect the general shares of consumption and investment in the economy. As a result, some 80 percent of the resources withdrawn for the greenhouse action is likely to come from consumption and only some 20 percent from investment. ... This is a reasonable global average. For the United States, the historical investment rate is closer to 15 percent to 17 percent of GDP.”

For the United Kingdom, Pearce and Ulph (1999) find a value of 0.17, which is the same as Moore et al. (2004) found for the United States. Finally, in his widely cited standard work on discounting (1982: 85), Lind gave a value of 0.2, although in 1990 (page S-16) he assumed a value of 0.1. The latter value relates more, however, to the marginal propensity of consumers to save out of disposable income only.

It should be noted that higher income groups generally save more than lower income groups (Dynan, Skinner, and Zeldes 2004) and that nations with a higher per capita GDP generally have a higher savings rate than low-income countries (Weil 2005: 70, based on Heston, Summers and Atten 2002). However, historical data gives no reason to assume that the savings rate likewise increases in step with growing per capita GDP (U.S. Census Bureau 2006: 875; Heston, Summers and Atten 2002). Given that the savings rate does not generally deviate far from 0.2, I shall assume that if case-specific information provides no evidence to the contrary, it is reasonable to assume that twenty percent of expenditure on climate mitigation is at the expense of alternative investments. Historical data provides no grounds for assuming this value will change substantially in the

(distant) future. Moreover, it is assumed that although the costs of climate policy may be substantial, the economic impacts will still be sufficiently small not to alter the savings rate. In the most recent IPCC report (2007), for example, the reduction of average annual GDP growth rates in 2030 is estimated at less than 0.12% to achieve stabilisation of concentrations at 445-535 ppm CO<sub>2</sub>-eq. (see also Azar and Schneider 2002).

Finally, in the absence of evidence to the contrary, it is reasonable to assume that invested capital remains fully invested and that the same fraction of 0.2 of the returns on investment is reinvested (Lind 1982; Mendelsohn 1981).

## 7. The rate of return on investment

How to estimate the rate of return on investment that will be achieved by refraining from climate mitigation? In this section, I shall first describe the approach in which the *expected* rate of return on private investment is used. Subsequently, I shall argue that both economic reasoning and legal practice provide grounds for using the *risk-free* rate of return instead. Please note that when I speak of *the* rate of return on private investment, this is short-hand for the marginal pre-tax net real rate of return on private investment:

- *marginal*, since it is the marginal investment that will be displaced if regular private investment is crowded out by investments to reduce climate risk. Most authors believe that the schedule for the marginal efficiency of capital slopes downward, and that therefore the marginal rate of return on investment will be less than the average rate of return (Lind 1982: 78-79; Cline 1992: 261-2; Arrow et al. 1996: 133 and 142 note 17; Poterba 1998: 14-15). See for doubts about the relevance of the difference between average and marginal rates of return: Stockfish 1982: 263;
- *pre-tax*, since the government's share of the return via corporate and private-income taxes goes into individual consumption as well taking the form of publicly provided goods and services (Lind 1982: 30);
- *net*, since part of the gross returns on investment is required to replace depreciated assets and therefore does not add to consumption;
- *real*, since the nominal return includes the impact of inflation, while the real rate measures the opportunity cost of foregoing consumption.

Some economists concern themselves with the rate of return that is *expected* on the basis of the empirical evidence of past rates of return, for which there are three basic sources (Nordhaus 1994: 125-129). In the first approach, used by Nordhaus in his DICE model, the rate of return is derived from economic

models using aggregate data on inputs of labour and capital, and estimates of the pure rate of time preference and the elasticity of the marginal utility of income. Nordhaus thus arrives at an average real return on assets of 6.3 percent during the period 1960-89.

In the second approach one looks at the rates of return in capital markets for financial instruments such as equities. These returns are highly volatile, since they include expectations of future performance. The real, post-corporate tax, pre-income tax annual returns of the Standard and Poor's index of the 500 largest companies (S&P 500) yield a geometric mean of 7% over the period 1926-2004 (Ibbotson Associates 1999; Standard and Poor 2005). Under the assumption of 35% corporate income taxes, the pre-corporate-tax return to large capitalization stocks would be around 11%.

In the third approach one looks at the actual 'accounting' returns to investments such as corporate capital. According to Poterba (1998), in the US the average pre-tax return on capital in the non-financial corporate sector averaged 8.5 percent over the period 1959-1996 (5.1% after corporate taxes). Elmendorf and Mankiw (1998: 21) estimate the net marginal pre-tax return on aggregate capital at 6 percent between 1960 and 1994 in the United States. In part, this lower estimate of the marginal product of capital reflects the fact that the return on capital in the non-corporate sector (e.g. housing) may be lower than in the corporate sector. Another influential source is the US Office on Management and Budget (1996):

"The discount rate specified in [OMB Circular A-94] is intended to be an approximation of the opportunity cost of capital, which is the before-tax rate of return to incremental private investment. The Circular A-94 rate, which was revised in 1992 based on an extensive review and public comment, reflects the rates of return on low yielding forms of capital, such as housing, as well as the higher rates of returns yielded by corporate capital. This average rate currently is estimated to be 7 percent in real terms (i.e., after adjusting for inflation)."

And: "In a recent analysis, OMB found that the average rate of return to capital remains near the 7 percent rate estimated in 1992" (OMB 2003).

Given the various kinds of empirical evidence of past rates of return, and the assumption that investments due to 'optimal' climate policy instruments will crowd out both low and high yielding forms of capital investments, OMB's current estimate of seven percent seems a reasonable estimate of the marginal pre-tax net real rate of return on private investment in the past as well as in the future.

At the same time, however, "past performance is no guarantee of future results", as investment funds always warn us. Likewise, the *actual* future return on investment achieved by refraining from climate mitigation may differ substantially from the *expected* figure of seven percent. Therefore, both economic theory and legal practice give governments reason

to estimate the return on investment achieved by refraining from climate mitigation not on the basis of the expected rate of return on average investment, but rather on the basis of the much lower *risk-free* rate of return, such as that on U.S. Treasury securities. Treasury securities are considered practically risk-free, as the government is able to create money to fulfil its debt obligations under virtually any scenario (Ibbotson Associates 1999).

The economic reasoning runs as follows (see e.g. Arrow and Lind 1970; Lind 1982; Lanzillotti and Esquibel 1990; Fisher and Romain, 1990: 146; Arrow 1995; Arrow et al. 1996; Knoll 1996: 314; Howarth 2003; Spackman 2004). Given the uncertainty surrounding predictions of climatic change, returns on investments in climate risk mitigation are probably even more uncertain than returns on conventional investments. However, to avoid comparing apples and oranges, i.e. costs and benefits with different risk characteristics, *and* to keep the analysis as transparent as possible, the approach commonly adopted in cost-benefit analysis is first to convert uncertain costs and benefits into certainty equivalents, *before* discounting the latter at a risk-free rate (Lind 1982; Arrow et al. 1996; Bazelon and Smetters 2001). The certainty equivalent is the guaranteed return that would make an individual indifferent between it and the uncertain outcome. For risk-averse individuals, the certainty equivalent would be lower than the expected value, because risk intrinsically has a negative value. The difference between the expected value of net benefits subject to risk and the certainty equivalent is called the risk premium (OMB 1996).

So the question of interest is what investment in climate risk mitigation ‘reasonable man’ should make to prevent a certainty equivalent of climate damage. This being our question, we are also looking for the certainty equivalent of the return on investment achieved by refraining from climate risk mitigation. This certainty equivalent is the *borrowing* interest rate, which in the case of the government is the rate of return on Treasury bonds. That the borrowing interest rate is the certainty equivalent of the expected rate of return on conventional investment is readily clarified: if the relatively low borrowing interest rate were to be valued less than the relatively high expected rate of return on conventional investments, then individuals and companies would start borrowing funds to increase investments *en masse*. The present equilibrium shows, however, that at the margin investors are indifferent between the risk-free rate of return or borrowing interest rate and investments in the corporate sector (Arrow and Lind 1970: 374-375; Arrow 1995). Therefore, climate damage is to be weighed against the consumption that is lost by borrowing funds either to finance climate damage prevention or to fund the alternative investments that would be lost by investing in such prevention. Any return on conventional investments over and above the risk-free rate is compensation for bearing risk, not a benefit of refraining from climate risk mitigation (Myers et al. 1997: 9).

Legal practice supports estimating the return on investment achieved by refraining from climate mitigation on the basis of the risk-free rate of return. Although courts have used a variety of approaches in the past, there are presently sufficient precedents to defend a risk-free rate (see e.g. Podolsky 2002; Fuhrman 2003). Imagine, for example, a defendant who for several years has been in unlawful possession of an asset, through theft or non-compliance with regulations. Holding the asset for this period has given the defendant the opportunity to invest. Under current law, the defendant can successfully claim that the only returns on investment to which the plaintiff is entitled are the risk-free returns. First of all, this view is contained in the U.S. federal pre- and post-judgment interest rate (US Courts 2006):

“Interest is allowed on most judgments entered in the federal courts from the date of judgment until paid. The types of judgments generally fall under one of three statutes: 28 U.S.C. 1961, which governs civil and bankruptcy adversary judgment interest; 18 U.S.C. 3612 (f)(2), which governs criminal judgments or sentences; and 40 U.S.C. 3116, which governs deficiency judgments in condemnation proceedings. ... Under each of the above statutes the rate of interest used in calculating the amount of post judgment interest is the weekly average 1-year constant maturity (nominal) Treasury yield, as published by the Federal Reserve System.”

Second, there are various cases in which courts have estimated the economic benefit of non-compliance with regulations using the risk-free rate of return as the pre-judgment interest rate. For example, in *United States v. WCI Steel, Inc.* (1999) the court had to choose a rate of return to calculate the present economic benefits accruing to WCI Steel through non-compliance with the National Emission Standard for Hazardous Air Pollutants for Asbestos:

“The central issue is whether a rate reflecting risk should be used as to past benefits or obligations. Any return above the risk-free rate is earned not from delay but by assuming risk, and therefore is not properly considered economic benefit from non-compliance. ... In determining economic benefit, the Court therefore finds an after-tax, risk-free rate is correct.”

In a 2003 case of non-compliance with regulations, the federal district court made the following ruling in *United States v. The New Portland Meadows LLC* :

“I also assume the United States Treasury’s short-term cost of capital for the calculations because I believe it results in a more reasonable economic benefit estimate [as a result of non-compliance].”

If a defendant can successfully claim that it is only the risk-free rate that may be taken as the economic benefit of non-compliance with regulations, then it

seems obvious that in determining ‘reasonable care’ the risk-free rate should be used as well. The point, therefore, is not that the climate-risk creator cannot expect higher returns from alternative investments, but that the risk premium should not enter into determination of ‘reasonable care’. Risk-related profits should be distinguished from the economic benefits of leaving climate risk be (Podolsky 2002: 1018).

In conclusion, since we are asking what figure should be spent on preventing the certainty equivalent of future climate damage, we are also looking for the certainty equivalent of the consumption lost through investment in climate damage mitigation. To calculate the certainty equivalent of this lost consumption, we need the risk-free rate of return on investment. At the time of this writing, the weekly average 1-year constant maturity (nominal) U.S. Treasury yield is about 5%. On the basis of the yields on Treasury Inflation-Protected Securities (TIPS), the present real risk-free rate of return is estimated at just over two percent (US Federal Reserve Board 2006). Because the average of the real interest rate on long-term Treasury securities between 1870 and 2000 is about three percent, the real interest rate is generally expected to be about three percent in the long term as well (US Department of the Treasury 2005).

## 8. Discussion and conclusion

In section 4, I stated that from the reasonable man perspective the sum of the consumption *before* the moment of climate damage and the investment still available *at* the moment of damage should outweigh the projected damage. If it does not, one has been negligent or *reckless* in more precise juridical terms given the foresight of climate risk. In the previous sections, I argued that reasonable man would estimate that about twenty percent of investment in climate change mitigation is at the expense of alternative investments and that these alternative investments obtain a two to three percent risk-free rate of return. Given these values, it can be shown that a reasonable man would apply a social discount rate in cost-benefit analysis equal to the rate of return on private investment times the extent to which alternative investment is displaced by expenditure on climate risk mitigation, i.e. about half a percent.

Half a percent is a much lower value than commonly used in cost-benefit analysis and may raise resistance on purely arithmetic grounds. A social discount rate of half a percent could lead to infinite marginal damage estimates of present carbon dioxide emissions if it is assumed that global GDP grows faster than the rate at which greenhouse gases are removed from the atmosphere, *and* if it is assumed that climate damage is directly proportional to GDP (Tol 2003). Under these assumptions, the damage due to a present emission of greenhouse gases would continue to grow forever and a social discount rate would be required to arrive at finite marginal

damage estimates of present carbon dioxide emissions. This arithmetic trick does not seem inevitable, however, since there are more reasons to consider for assuming that future impacts will be both higher and lower than if they were to occur today. On the one hand, rich societies tend to have a higher willingness to pay for a clean environment and intact nature (Manne 1999; Horowitz 2002). On the other hand, rich societies are less vulnerable to climate change (Yohe and Tol 2002; Adger 2006, Smit and Wandel 2006). The share of climate-sensitive sectors such as agriculture will diminish and the vulnerability will diminish, for example through technological progress and adaptation (Yohe and Tol 2002). All these effects are uncertain. To a large extent, however, these countervailing effects are coupled (Smit and Wandel 2006). Vulnerability will decrease and adaptation increase more rapidly with economic growth. Given this coupling and the lack of quantitative information (see for an exception: Tol 2002), I do not see sufficient reason to assume that in the future climate change will have different overall impacts on consumption than the same climate change would have today. Consequently, on the basis of presently available information it does not appear to be reckless for reasonable man to take precautions as if the future were like the present, apart from climate change. In that case, the impacts of a present emission of greenhouse gases diminish in the distant future solely at the rate at which these gases are removed from the atmosphere, and there is no need for a social discount rate on purely numerical grounds to arrive at finite results.

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