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Positional goods, climate change and the social returns to investment

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Abstract

The economic analysis of global warming is dominated by models based on optimal growth theory. This approach can generate biases in the presence of positional goods and status effects. We show that by ignoring these direct consumption externalities, integrated assessment models overestimate the social return to conventional investment and underestimate the optimal amount of investment in mitigation. Empirical evidence on the influence of relative consumption on utility suggests that the bias could be quantitatively significant. Our results from a simple survey support this conclusion.

JEL classification: Q13, I3, E1

Key words: representative agent, consumption externalities, positional goods, relative consumption, welfare, global warming, discount rates.

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1 Introduction

Climate change affects countries differently, and within regions the impact varies across groups. The time dimension introduces other distributional elements: the costs of global warming are born (mainly) by future generations while the investment in mitigation may impose costs on the current generation.

The uneven distribution of costs and benefits is not unique to climate change and environmental policy. Policy generally benefits some people while others are hurt, and Pareto rankings of the outcomes are typically not available. Instead, decisions have to be based on social welfare evaluations that make (implicit or explicit) interpersonal comparisons, weighing up costs and benefits so as to arrive at a net result. The standard approach in the economic literature on climate change has been to use the utility function of 'the representative agent' as a social welfare function.

The approach is in line with trends within macroeconomics where models based on an optimizing representative agent are ubiquitous. The models are seen as 'micro-founded', even though well-behaved preferences at the agent level fail to imply that aggregate outcomes behave as if they were generated by an optimizing representative agent, a result that has been well-known since the work of Debreu (1974), Mantel (1976) and Sonnenschein (1972). Abstracting from these existence problems, the preferences of the representative agent may seem to provide the appropriate way to measure social welfare. The analysis can lead to systematic biases, however. In this paper we focus on the intertemporal dimension and the biases that arise when consumption has a positional component. To simplify the analysis and highlight these particular effects, we disregard problems associated with intra-generational distribution and assume that all agents are identical with respect to both preferences and endowments; Skott and Davis (2011) examine biases that derive from intra-generational inequality.

The paper is in five sections. Section 2 considers representative agents and the role of the rates of return. Section 3 introduces positional goods and sets up a small model to analyze how they affect the optimal amount of investment in mitigation. Section 4 relates the formal model to procedures used in climate models to evaluate the costs and benefits of mitigation, and presents the results of a small survey to evaluate the importance of the biases identified by the model. Section 5 summarizes the results and offers a few concluding remarks.

2 Representative agents and rates of return

Consider a market economy and assume that the trajectories of aggregate consumption, investment and output can be described as if determined by an intertemporally optimizing representative agent. Given this highly restrictive assumption, it may seem reasonable to use the utility function of the representative agent as the social welfare function. Woodford (2003 p. 12; emphasis added), for instance, suggests that the utility function of the representative agent "provides a *natural objective* in terms of which alternative policies should be evaluated", while, according to Blanchard (2008, p. 9, emphasis added), contemporary macro models with formal optimization enable one "to derive optimal policy based on the *correct* (within the model) welfare criterion". Most tellingly, perhaps, the evaluation of outcomes based on the stipulated utility function of the representative agent is usually

presented without any argument or caveat.[1]

Using this 'descriptive' representative-agent approach, the social welfare function has to be calibrated to fit empirical observations.[2] An optimizing representative agent in a standard discounted-utility model chooses a consumption path that satisfies the Euler equation

$$\hat{c} = \frac{1}{\theta}(r - \rho) \tag{1}$$

where c is consumption and a hat over a variable denotes a growth rate ($\hat{c} = \frac{dc}{dt}/c$); ρ is the pure rate of time preference, θ the intertemporal elasticity of substitution and r the real rate of return on saving. We have observations for r and $\hat{c}$, and the choices of the representative agent should match these observations. It follows that although the social welfare function has two parameters, θ and ρ, there is only one degree of freedom.

Most economic analyses of climate change have followed the descriptive approach. The Stern Review (Stern 2007) is an exception. Stern adopted a 'prescriptive' approach to social welfare and argued that on ethical grounds the pure discount rate should be close to zero. He combined the low discount rate with a logarithmic specification of the instantaneous utility function ($\theta = 1$), and this combination of parameters fuels the strong recommendations of the Stern Review.

Not surprisingly, Stern's assumptions have been challenged. Nordhaus (2008) rejects Stern's "lofty vantage point of the social planner" as being "misleading in the context of global warming and particularly as it informs the negotiations of policies among sovereign states" (p. 174). Advocating a descriptive approach, Nordhaus wants to base the analysis on the revealed preferences of the representative agent. This approach, he argues, does not assume "the social desirability of the distribution of incomes over space or time under existing conditions". Instead,

> The calculations of changes in world welfare arising from efficient climate-change policies examine potential improvements within the context of the existing distribution of income and investments across space and time. (Nordhaus, 2008, p. 174-175)

There is an internal tension in Nordhaus's defense of the descriptive approach. He also argues that

> The individual rates of time preference, risk preference, and utility functions do not, in principle at least, enter into the discussion or arguments at all. An individual may have high time preference, or perhaps double hyperbolic discounting, or negative discounting, but this has no necessary connection with how social decisions weight different generations. Similar cautions apply to the consumption elasticity. (p. 172)

It seems inconsistent, however, to argue that there is "no necessary connection" between individual choice and the appropriate criteria for social decisions and, at the same time, insist

[1] Nordhaus (2008, p. 39) simply comments that

> policies are chosen to maximize a social welfare function that is the discounted sum of the population-weighted utility of per capita consumption. Equation (A.1) is the mathematical statement of the objective function. This representation is a standard one in modern theories of optimal economic growth.

[2] The 'prescriptive'/'descriptive' terminology is used by Arrow at al. (IPCC chapter 4, 1996).

on a descriptive representative-agent approach to social valuation. The rationale behind the descriptive approach is precisely that the representative agent describes the average behavior of the individuals; why insist on the descriptive approach if individual choices are irrelevant?

Leaving aside this inconsistency, Stern's combination of a logarithmic utility function and a near-zero discount rate fails to meet the descriptive test if the annual real rate of return is taken to fall in a range that matches the observed return on private capital.[3] More importantly, whatever one may think about ethics and the pure rate of discount, there is a tradeoff, Nordhaus argues, between investment in mitigation and investment in other areas including traditional capital, R&D, education etc. If r measures the social rate of return to these conventional investment projects, investment in emissions reduction must get a similar return:

> In choosing among alternative trajectories for emissions reductions, the key economic variable is the real return on capital, r, which measures the net yield on investments in capital, education, and technology. In principle, this is observable in the marketplace. ... The return on capital is the discount rate that enters into the determination of the efficient balance between the cost of emissions reductions today and the benefit of reduced climate damages in the future. A high return on capital tilts the balance toward emissions reductions in the future, while a low return tilts reductions toward the present. (Nordhaus 2008, p. 59)

According to Nordhaus, the Stern Review with its low discount rate for investment in abatement would misallocate investment to such an extent that an attempt to maintain the welfare of current generations "would leave the future absolutely worse off; it would be Pareto-deteriorating. The Stern Review's approach is inefficient because it invests too much in low-yield abatement strategies too early" (p. 180). Looking at this from another angle, the Stern parameters have implications for the optimal levels of conventional investment. Using these parameters and the observed values of the return to capital, the optimal global saving rate would be about twice the current level, an implication that does not, Nordhaus suggests, seem "ethically compelling" when global per capita consumption is expected to grow from around $6,600 today to around $87,000 in two centuries measured in constant 2005 dollars (Nordhaus 2008, p.179).

This general argument has considerable appeal.[4] But it relies on the implicit assumption that socially optimal trajectories require an expected rate of return to mitigation that is (approximately) equal to the observed private rate of return on capital. This assumption may be invalid. As pointed out by Weitzman (2007, 2009), the returns to mitigation may be high in bad states of the world, and this can dramatically reduce the appropriate discount rate for investment in abatement. Michl (2010) also comments on the use of the rate of return on private capital as the basis for discounting mitigation. He notes in particular the implications of the capital controversy for the identification of the rate of return on capital with a 'marginal product of capital'. Like these contributions, our argument in this paper focuses on the appropriate discount rate for investment in mitigation and, like Weitzman, we argue that it is much lower than the private real rate of return. But the mechanism is

[3] This is the range used by Nordhaus (2008); see e.g. p. 57.

[4] It appears to be in line with Rezai et al. (2011). The pure discount rate and the tradeoff between current and future generations are not nearly as important as is commonly believed, they argue. The real question is whether the composition of investment should be changed, and starting from a business-as-usual case in which all investment is guided by private profit, the answer is yes: addressing the climate externality can lead to Pareto improvements if some investment is re-directed from conventional areas to mitigation.

different.[5]

Environmental externalities are not the only externalities. Utility derives not just, or even primarily, from absolute consumption, once a certain level has been reached. The level of consumption relative to other people and relative to own past consumption may be at least as important. A substantial literature has emphasized these effects,[6] and the argument has empirical support. Recent empirical studies have shown a high correlation between relative income and reported well-being; prominent examples include Blanchflower and Oswald (2004) who examine data for the US and UK, Luttmer (2005) with US data, and Fafchamps and Shilpi (2008) with data for Nepal. The use in these studies of reported 'well-being' or 'happiness' as a measure of utility raises many issues, but it would be hard to reject the influence of relative income and status on utility, and 'happiness' studies are not the only source of empirical support.[7] Johansson-Stenman et al. (2002) analyze experimental choices between hypothetical societies and find a strong concern for relative income. Evidence from the experimental and behavioral literature also suggest that 'social preferences' shape the behavior of many people (Fehr and Schmidt 2003).

The relevance of status and relative income effects for economic policy has been examined by among others Ng and Wang (1995) and Howarth (2000), but to our knowledge there has been no attempts to analyze the implications for climate change and the appropriate discount rate for investment in abatement.

3 A model

Consider a simple two-period model. There are two goods, a standard good and an environmental good. The standard good (y) is a private good, but the consumption of this good involves a positional element and increased consumption imposes a negative externality on other agents. We disregard the uneven distribution of the effects of climate change and treat the environmental good as a pure public good.

All agents are identical, and the preferences of an agent can be described by the following utility function

$$U = u(c_0^k, c_0, x_0) + \frac{1}{1+\rho} u(c_1^k, c_1, x_1) : \qquad u_1 > 0, u_2 < 0, u_3 > 0 \tag{2}$$

where $u(.,.,.)$ is the per-period utility function; c is the consumption of the standard good and x the environmental good; superscripts k indicate agent and subscripts on a variable (0 or 1) indicate period; $c-$variables without a superscript refer to average consumption across

[5]The discount rate is not the only variable that matters for optimal mitigation. The specification of the damage function can produce dramatic effects on optimal mitigation. Thus, Rezai et al. (2011) use a version in which the proportional effect on output of an increase in atmospheric CO_2 goes to infinity as the CO_2 concentration approaches a a finite level (which is set at just over twice the current level in their simulations). This assumption, which is quite different from the specifications in DICE (the Dynamic Integrated model of Climate and the Economy developed by Nordhaus), contributes to the contrast between their findings and those of Nordhaus. As pointed out by Weitzman (2009, p. 16) the damages at high CO_2 concentrations are typically found by extrapolation using a functional form that is largely arbitrary, and there is little justification for the standard versions.

Ackerman et al. (2010) modify the standard Nordhaus-type assumptions in another direction by respecifying the costs of abatement, using estimates from a study by McKinsey & Co.

[6]The contributions include Veblen (1899), Duesenberry (1949), Sen (1983), Easterlin (1974, 2001), Frank (1985, 2005) and Hirsch (1977).

[7]Frey and Stutzer (2002) survey the behavioral literature on 'happiness'.

all agents; by definition the consumption of the public environmental good x is uniform across agents.

The standard good can be used for either consumption, conventional investment (i) or investment in abatement (m), and we assume

$$c_1^k = F(i_0^k); \qquad F' > 0 \tag{3}$$

$$x_1 = G(i_0, m_0); \qquad G_1 < 0, G_2 > 0 \tag{4}$$

$$y_0^k = c_0^k + i_0^k + m_0^k \tag{5}$$

$$c_0^k \geq 0, i_0^k \geq 0, m_0^k \geq 0 \tag{6}$$

Note that agent k's consumption of the standard good in period 1 depends on the agent's own investment while the consumption of the environmental good is determined by aggregate conventional and abatement investment. The amounts y_0 and x_0 of the standard and environmental good that are available in period 0 are taken as exogenous, and all agents have the same initial endowment of the standard good ($y_0^k = y_0$).

We now consider 4 different scenarios:

A: **Business as usual**

Without policy intervention, agents maximize (2) subject to (3)-(6). It is readily seen that the solution has $m_0^k = 0$ and that it satisfies a standard Euler equation

$$u_1(c_0^k, c_0, x_0) = u_1(c_1^k, c_1, x_1)\frac{F'(i_0^k)}{1+\rho} \tag{7}$$

where subscripts on a function indicate partial derivatives (e.g.$u_1 = \partial u(c_0^k, c_0, x_0)/\partial c_0^k$). In equilibrium, $c_j^k = c_j$ and $i_0^k = i_0$, and we have

$$u_1(c_0, c_0, x_0) = u_1(c_1, c_1, x_1)\frac{F'(i_0)}{1+\rho} \tag{8}$$

B: **Addressing the environmental externality**

A benevolent social planner should take into account both the environmental externalities (equation (4)) and the positional-good externality ($u_2 \leq 0$). But consider first the case in which the social planner overlooks the positional-good externality; that is, she mistakenly believes that $u_2 = 0$.

Social welfare is given by

$$U = u(c_0, c_0, x_0) + \frac{1}{1+\rho}u(c_1, c_1, x_1): \qquad u_1 > 0, u_2 \leq 0, u_3 > 0 \tag{9}$$

Maximizing (9) subject to (3)-(6) and the symmetry condition ($c_j^k = c_j, i_j^k = i_j, m_j^k = m_j$), and setting $u_2 = 0$, we get the following first-order conditions:

$$u_1(c_0, c_0, x_0) = \frac{u_1(c_1, c_1, x_1)F'(i_0) + u_3(c_1, c_1, x_1)G_1(i_0, m_0)}{1+\rho} \tag{10}$$

$$u_1(c_0, c_0, x_0) = \frac{u_3(c_1, c_1, x_1)G_2(i_0, m_0)}{1+\rho} \tag{11}$$

C: **Addressing the positional-good externality**

In this case, the social planner overlooks the environmental externality. Equation (4) is ignored and the values of both x_0 and x_1 are treated as exogenous. The planner therefore sets $m_0 = 0$ and chooses i_0, c_0 to maximize (9) subject to (3), (5)-(6) and the symmetry condition.

The first-order condition in this case becomes

$$u_1(c_0, c_0, x_0) + u_2(c_0, c_0, x_0) = [u_1(c_1, c_1, x_1) + u_2(c_1, c_1, x_1)]\frac{F'(i_0^k)}{1+\rho} \tag{12}$$

D: **Addressing both environmental and positional-good externalities**

The first order conditions now take the following form:

$$\begin{aligned} u_1(c_0, c_0, x_0) + u_2(c_0, c_0, x_0) &= \frac{[u_1(c_1, c_1, x_1) + u_2(c_1, c_1, x_1)]F'(i_0)}{1+\rho} \\ &\quad + \frac{u_3(c_1, c_1, x_1)G_1(i_0, m_0)}{1+\rho} \end{aligned} \tag{13}$$

$$u_1(c_0, c_0, x_0) + u_2(c_0, c_0, x_0) = \frac{u_3(c_1, c_1, x_1)G_2(i_0, m_0)}{1+\rho} \tag{14}$$

Comparing scenarios A and B, the climate externality tends to reduce the optimal amount of conventional investment (use equations (9) and (10) and note the negative impact of i_0 on x_1 via G_1 in the numerator on the right hand side of (10)), and equation (11) implies positive amounts of investment in mitigation if u_3G_2 is sufficiently high at $m_0 = 0$. These are standard results.

The positional-good externality in scenario C may influence the optimal rate of investment, but in benchmark cases – including when u is CES – the optimal solution is identical to the one in the A scenario.[8] The intuition behind this seemingly paradoxical result is that although the benefits from future increases in consumption are reduced by the externalities, so are the costs from the required reduction in consumption, and these cost and benefit effects offset each other.

Comparing cases B and D, however, it is apparent that the consumption externalities become important for optimal investment when environmental externalities are present too. Formally, this can be seen by noting that there are the same coefficients on G_1 in the numerator on the RHS of (10) and (13). Intuitively, the consumption externalities do not reduce the negative impact of current investment on future consumption of the environmental good and this reduces the optimal value of i_0. The optimal investment in mitigation, on the other hand, is boosted by the reduction in the social cost of a reduction in the period-0 consumption of the standard good (equations (11) and (14) have the same RHS but the LHS has been reduced in (14)).

A special case

[8] The conditions (8) and (12) are equivalent if there is a constant λ such that

$$u_2(c, c, x) = \lambda u_1(c, c, x)$$

for all c, x. This condition is met for the CES specification of u,

$$u = [\alpha_1(c^k)^\delta - \alpha_2 c^\delta + \beta x^\delta]^{1/\delta}$$

Consider a special case in which the standard and environmental goods are perfect substitutes. Thus, let

$$u(c^k, c, x) = v(z) \tag{15}$$

where

$$z = c^k - \gamma c + x \tag{16}$$

is the amount of 'generalized consumption' and where it is assumed that v takes the standard CIES form.[9]

Using these specifications the first-order conditions – taking into account both consumption and environmental externalities – can be written

$$v'(z_0)(1-\gamma) = \frac{v'(z_1)}{1+\rho}((1-\gamma)F' + G_1) \tag{17}$$

$$v'(z_0)(1-\gamma) = \frac{v'(z_1)}{1+\rho}G_2 \tag{18}$$

Hence, optimality requires that

$$G_2 = (1-\gamma)F' + G_1 \tag{19}$$

Equation (19) states the required equality between the social rates of return to the two types of investment. $G_2 = \partial z_1/\partial m_0$ is the return to investment in mitigation. The gross private return to conventional investment is given by $\partial z_1^k/\partial i_0^k = F'$; including the environmental externality the social return is reduced to $F' + G_1$, and consumption externalities introduce an additional wedge: the social benefits of a increase in the consumption of the standard good is reduced by the factor $1-\gamma$.

Any mapping of this stylized two period model into real-world decision problems raises problems, but equation (19) can be used to derive a quick back-of-the-envelope estimate of the magnitude of the positional-good effect. Thus, consider a period length of 50 years, let the annual private return to conventional investment be 6 percent, and assume that this return is reduced to 5 percent when the environmental externality is included (i.e. $F' = \exp(rT) = \exp(0.06 \times 50)$, $\quad F' + G_1 = \exp(0.05 \times 50)$). If $\gamma = 0.5$, equation (19) implies that the required annual return to environmental investment is 1.5 percent,[10] a value that is virtually identical to the one used by the Stern Review.[11]

The special case has wider relevance. Consider a more general specification of 'generalized' consumption. Formally, let

$$u(c^k, c, x) = v(z) \tag{20}$$

$$z = H(c^k, c, x) \tag{21}$$

In terms of generalized consumption goods, the private return to conventional investment now is given by H_1F'; taking into account the environmental externality, the return in terms of generalized consumption goods is $H_1F' + H_3G_1$, and when both externalities are included

[9] The unit coefficient on c^i and x can be obtained by an appropriate choice of units. Thus, there is no loss of generality in using (16) rather than $z = \alpha c^i - \gamma c + \beta x$.

[10] Solve the equation

$$\exp(r_m \times 50) = (1-\gamma)F' + G_1$$

[11] Stern's benchmark assumptions are $\rho = 0.1\%, \theta = 1$ and $\hat{c} = 1.3\%$, with an implied r-value of 1.4.

the return falls to $(H_1 + H_2)F' + H_3G_1$. Optimality requires that this expression equal the return to investment in abatement which, in terms of the generalized good, is now H_3G_2.[12] Formally, using (13)-(14) and (20)-(21), the first-order conditions imply

$$H_3G_2 = [H_1 + H_2]F' + H_3G_1 \tag{22}$$

This optimality condition can be rewritten

$$H_3G_2 = [1 + \frac{H_2}{H_1}]H_1F' + H_3G_1 \tag{23}$$

Equation (23) differs from (19) in two ways. The expressions for the returns in terms of generalized consumption, first, are slightly more complicated (H_3G_1, H_3G_2, H_1F' instead of G_1, G_2,F'); this difference is of no significance. The ratio $-H_2/H_1$, secondly, takes the place of the constant γ. In equilibrium, however, we have $c^k = c$ and the ratio will be constant if H takes a standard CES form: if $H(c^k, c, x) = [\alpha_1(c^k)^\delta - \alpha_2 c^\delta + \beta x^\delta]^{1/\delta}$ we have

$$-H_2/H_1 = \frac{\alpha_2(c^k)^{\delta-1}}{\alpha_1 c^{\delta-1}} = \frac{\alpha_2}{\alpha_1} = \gamma \tag{24}$$

The benchmark case with $\gamma = 0.5$ is in line with the evidence. The empirical studies by Blanchflower and Oswald (2004), Luttmer (2005), and Fafchamps and Shilpi (2008) estimated a Cobb-Douglas utility function (a special case of the CES function),

$$H(c^k, c, x) = (c^k)^\alpha c^{-\gamma} x^\beta \tag{25}$$

Blanchflower and Oswald obtained estimates for $-H_2/H_1$ of about 0.4 while Luttmer and Fafchamps and Shilpi found values of about 0.75 or higher. The experimental approach in Johansson-Stenman et al. (2002) gave estimates of about 0.35.

Our analysis of positional goods, it could be argued, does not necessarily invalidate a representative-agent approach. In fact, our model has been cast in terms of identical agents. But a representative-agent analysis easily goes wrong. Thus, assume for the sake of the argument that the model in this section gives an accurate picture of the economy. In equilibrium $c^k = c$ and the welfare of the representative-agent can be written as a reduced-form function of conventional and environmental consumption,

$$W = w(c_0, x_0) + \frac{1}{1+\rho} w(c_1, x_1) \tag{26}$$

Using the descriptive approach and the general specification (26), it is required that the properties of W match the observed behavior, that is, it is assumed that observed consumption patterns can be derived from maximizing W subject to the relevant constraints. This assumption is invalid. The patterns of actual consumption in the business-as-usual regime are the same no matter how strong is the consumption externality (the value of γ in the special case above), and this observational equivalence implies that the correct parameters in the welfare function cannot - as a matter of principle - be decided on the basis of the macroeconomic evidence. In this sense the 'descriptive approach' is intrinsically flawed. Moreover, if (26) is fitted to the macroeconomic evidence, the positional externalities fail

[12] Strictly speaking, these expressions give the returns in terms of generalized consumption to the investment of one unit of the standard good. The return to the investment of one uit of the generalized good can be obtained by adjusting the expressions using the common factor $(\partial z_0/\partial c)^{-1}$.

to be incorporated and the welfare conclusions will be systematically biased. Putting it differently, in equilibrium the correct representation of the social welfare may take the form (26) whether or not there are consumption externalities. But the calibration of (26) to the evidence is only legitimate in the absence of consumption externalities.

4 A survey

Climate change influences the production of some market goods - agricultural output is the obvious example - but many of its effects concern non-market 'goods' like climate related diseases. In order to incorporate environmental externalities into existing economic models, monetary values have to be determined for the non-market effects. These values are assigned by estimating either individuals' willingness to pay for the environmental goods or their willingness to accept compensation for damages.

The estimates are based on either stated preference or revealed preference techniques. Revealed preference techniques use market information associated with the effect being evaluated to infer a monetary value - i.e. "surrogate markets" are used to value non-market environmental goods (IPCC Working Group III, 1996, p. 184). Hedonic wage studies, for example, use market information on wage differentials to derive estimates for the value of a statistical life. These market-based revealed preference techniques are limited in scope as it is often difficult to find relevant market information with which to infer a monetary value for the non-market good or service in question. As such, costs and benefits are often estimated using the contingent valuation method, whereby monetary values are assigned according to individuals' stated willingness to pay or willingness to accept compensation. Thus, the values depend on what individuals' behavior would have been if markets for the environmental goods and services had existed - through what the IPCC terms "hypothetical markets" (p. 184). Hypothetical markets reflect individuals' responses to questions regarding their personal willingness to pay, and"monetary estimates are thus able to cover both market and nonmarket impacts" (p. 183).

The procedure requires a delineation of the target population, i.e. those individuals must be identified that are affected by the environmental effect. Willingness to pay is estimated using surveys that directly ask respondents how much they are willing to pay, and these individual responses are aggregated to determine total willingness to pay, from which monetary values are inferred. The resulting evaluations can be questioned (see for example Venkatachalam, 2004; Ackerman and Heinzerling 2004). Willingness to pay fundamentally reflects ability to pay, and the preferences and values of the rich are thus inherently over-represented relative to those of the poor. At a more technical level, contingent valuation surveys suffer from potential biases arising from incentives to misrepresent preferences or from implied cues within the survey design that prompt certain responses (Mitchell and Carson, 1989).[13]

[13]The IPCC notes that, "although controversial, these approaches are well established in the literature" (p. 184). Similarly, Nordhaus's estimates of the impacts of climate change rely on a willingness to pay approach (Nordhaus, 2000, p. 71). While Nordhaus writes that valuation techniques with "an objective behavioral component, whether in market prices or individual actions" are generally preferable since "Valuation techniques that are largely subjective - such as contingent valuation - are difficult to validate", he also notes that techniques like contingent valuation are "needed in some areas" (Nordhaus 2006, p. 151). Impacts - which are calculated by sector - are estimated through an impact index that represents "the fraction of annual output that subregion j would be willing to pay to avoid the consequences on sector i of a temperature increase of $T°C$" (73). These impacts are then used to estimate the damage functions, which indicate the percent loss in output at different levels of global temperature increase. Thus, while

The positional character of consumption and the importance of own past consumption as another reference point can impart additional biases. A higher willingness can be expected, first, if it is clarified that everyone shares in the mitigation effort (the positional effect).[14]Secondly, framing the question as a reduction in the growth rate of traditional consumption may also raise willingness to pay in comparison to a question defined in terms of a lower level of traditional consumption (the effect of own past consumption as a reference point).

We carried out a simple survey to preliminarily investigate this hypothesis. The survey considers a particular environmental change. The subjects are informed that global warming and other environmental changes threaten the survival of some animal species and that, according to some estimates, as many as 25 percent of all species will be extinct before 2100 under current trends. Policy intervention, it is added, may change the scenario and ensure the survival of these endangered species.

The purpose of the survey is not to value environmental goods or damages, but to investigate the role of positional effects in individuals' willingness to pay. As such, what is important is not the exact loss that respondents are willing to accept to protect the environment, but any systematic differences between willingness to pay when costs are individual and when costs are shared. The extinction of species was chosen as a simple and concrete example of a pure public good threatened by global warming.[15]

The presentation of the environmental problem — the extinction of the species — was followed by a willingness-to-pay question. We used three different versions of the question. In a first version, respondents were asked how large a proportion of their stream of current and future income they would be willing to give up in order to ensure that no existing species become extinct. A second version asked how large a proportion of current and future incomes should be given up to ensure that no existing species become extinct, now supposing that the costs of intervention are shared such that all incomes are reduced by the same percentage. These two questions highlight the difference between a single individual's willingness to pay for environmental protection, and the willingness to pay for environmental protection when there is no relative loss in income.

A third version of the question defined the issue in terms of reductions in the future growth rate of income, rather than in terms of reductions in income levels. Again the losses are to be shared - everyone will experience the same reduction in future income growth. The question is constructed such that the intervals describing reductions in the future growth rate of income roughly correspond to the intervals describing reductions in the level of the current and future income stream. Exact correspondence between levels and growth rates depends on the discount rate and the growth rate — specifically the difference between the two — and the time horizon. Table 1 in the appendix shows the growth reductions consistent with various parameters.[16]

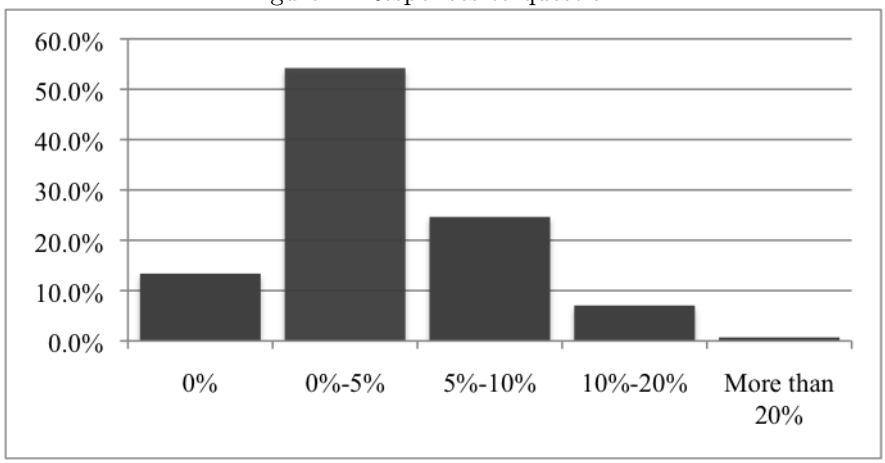
many impacts are measured using surrogate markets, hypothetical markets and contingent valuation remain a commonly used method by which to evaluate and incorporate non-market costs of climate change into analysis.

[14]Evidence based on actual behavior - e.g. wage premia for risky jobs as an indicator of the value of life - also suffers from this bias. It reflects individual behavior which (by definition) does not internalize the externalities associated with positional goods.

[15]While some respondents commented that they did not have a high willingness to pay because some threatened species are likely to be entirely irrelevant to their own future wellbeing, use of a more dramatic example (that may enter more directly into respondents' utility functions) is likely to detract from and complicate the interpretation of the results. We wanted a climate effect that is well-defined and that has a clear public-good character.

[16]The upper limits in the growth formulation are somewhat higher than in the level formulation for most

Figure 1: Responses to question 1



The survey was carried out in March 2011. It was answered by a total of 496 students, 142 of which received question 1, 192 of which received question 2, and 162 of which received question 3. The participants were UMass students in large introductory classes on microeconomics and macroeconomics; teaching assistants administered the survey, and each discussion section was randomly assigned one of the questions (all students in a section received the same question). The questions are reproduced in the appendix.

The first issue is whether individuals are more willing to give up income in order to protect the environment if the costs are shared and their relative position is maintained (the positional effect). As expected, the survey indicates that sharing increases the willingness to pay. When the loss is individual, approximately 54 percent of respondents said that they would be willing to give up zero to five percent of their current and future stream of income in order to prevent the extinction, while 25 percent of respondents would be willing to give up five to ten percent of their current and future income stream (see Figure 1). When the payment is to be shared, on the other hand, the percentage of respondents who were willing to give up five to ten percent of current and future incomes increases to 41 percent (see Figure 2). Thus, the standard estimates of willingness to pay for environmental goods used in climate change analysis may be skewed downwards.

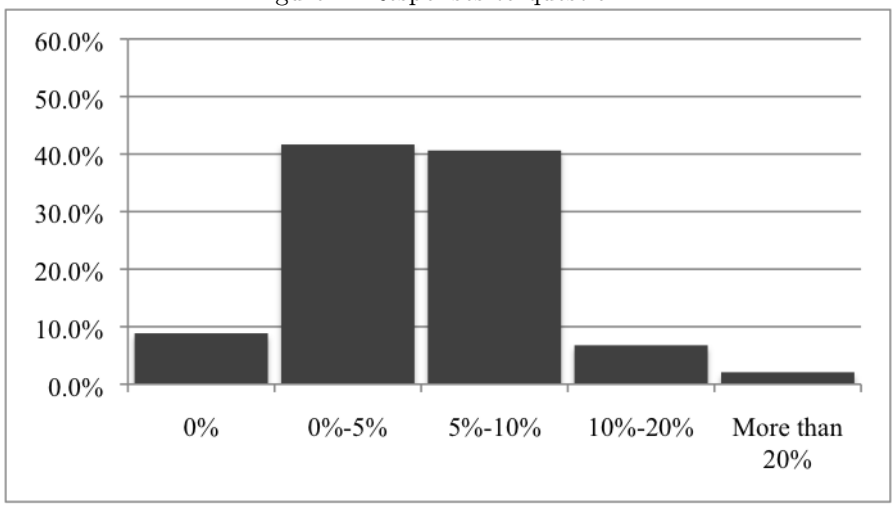
The results may support the existence of positional externalities in consumption. The outcome may also, however, be interpreted to indicate other effects including, importantly, concerns for fairness.[17] The distinction between positionality and fairness concerns will be important for some purposes, but the implications for the valuation of environmental goods is similar: there will be a higher willingness to pay when costs are shared.

The first two versions of the question are framed in terms of levels, and it is possible that respondents interpreted the questions to require an absolute decline relative to their current

reasonable parameters. This choice was deliberate. Since we expect higher willingness to pay in the case of growth reductions, responses to the third question that are concentrated in the upper intervals are consistent with an even greater willingness to pay for environmental protection in the context of growth rather than level reductions - i.e. the bias incorporated in the intervals would further support the hypothesis.

[17] These results may also indicate other effects including, for example, a 'small number effect' if respondents feel that a 0-0.1 percentage points decline in income growth is small relative to the equivalent loss in income levels.

Figure 2: Responses to question 2

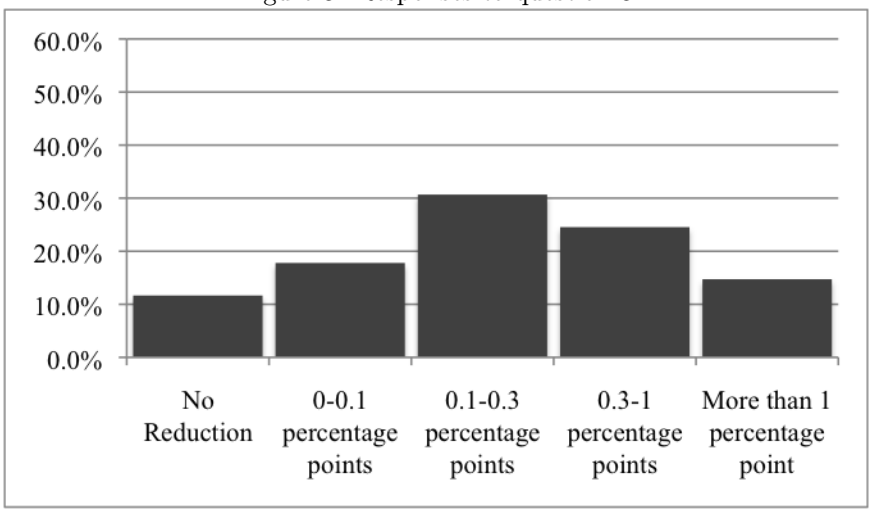


income and/or as a "loss"of income that has already been earned. Consumption is valued not just relative to other people's consumption, but also in relation to own past consumption. Loss aversion is well documented in the behavioral economics literature — people tend to place more value on avoiding losses than on acquiring gains (Tversky and Kahneman, 1991) — and if the cost of environmental protection is understood to require a level reduction in take-home pay, concerns regarding ability to meet other financial commitments such as mortgage payments or car payments may decrease willingness to pay. On the other hand, if the question is defined in terms of a lower future growth rate of income — implying lower future income gains instead of a future income loss — loss aversion may not be expected to play a significant role. Thus, one might expect people to be more willing to pay for environmental protection if the cost is framed not as a loss in the level of income but as a smaller future increment in income.

Figure 3 shows the responses to the third version of the question. Only 18 percent of respondents said that 0 to 0.1 percentage points of income growth should be given up to ensure the survival of species endangered by climate change (corresponding to a 0 to 5 percent reduction in future levels of income) - a rate considerably lower than with either of the two previous questions. In contrast, 31 percent of respondents would be willing to accept a 0.1 to 0.3 percentage point reduction in future income growth (corresponding to a 5 to 10 percent reduction in future levels of income), and 25 percent of respondents would be willing to accept a 0.3 to 1 percentage point reduction in future income growth (corresponding to a 10 to 20 percent reduction in future levels of income). In the second question (in which the costs are to be shared and the question is asked in terms of levels), while 41 percent of respondents thought we should give up 5 to 10 percent of future income growth to prevent the extinction, only 7 percent of respondents were willing to give up 10 to 20 percent of future income. Finally, while approximately 2 percent of respondents were willing to give up more than 20 percent of future incomes to prevent the environmental damage, 15 percent of respondents were willing to make the corresponding payment when the question is defined in terms of growth rates.

As the objective of the survey is not to determine a monetary value for the species that

Figure 3: Responses to question 3



potentially face extinction as a consequence of climate change, the exact intervals in the questions are unimportant. The important point is that the results indicate a significantly higher willingness to pay for environmental protection when the costs are to be shared equally among the population and thus entail no relative loss in income and, furthermore, that this higher willingness to pay is even more substantial when the costs take the form of slower future growth rather than a level reduction in current and future incomes. The mean and median responses to question 3 are more than double those to question 1.[18]

5 Conclusion

It is sometimes suggested that the science behind climate change may be weak but that the economics in the integrated assessment models is well-established and sound. We are not in position to evaluate the science but well-established as it may be, the economics is questionable. Weitzman (2009) has emphasized the treatment of catastrophic risk, and Rezai et al. (2011) and Ackerman et al. (2010) find that changes in some of the specifications give results that are dramatically different from those of Tol and Nordhaus.

This paper has raised a different concern. Consumption externalities associated with positional goods and status concerns are well-documented. Using a simple two period model we have shown that the interaction between these consumption externalities and environmental externalities has implications for the appropriate discount rate: the required return on investment in mitigation is lower than the private return to conventional investment. The magnitude of the difference depends on the weight of positional consumption in utility. An empirical literature has examined this question, and using estimates from this literature, the effect on the appropriate discount rate is quantitatively highly significant. This conclusion finds support in our survey of willingness to pay. Subjects show a much greater willingness to pay when the costs are shared and when the costs are expressed in terms of lower future

[18] Assuming a uniform distribution within each interval and setting $\rho - g = 3\%$, the means are 4.46, 5.7 and 10.8, respectively, for questions 1, 2 and 3.

growth, rather than reductions in the level of income. Overall, the results suggest that incorporation of consumption externalities into climate change analysis may have important implications for the calculation of the social costs and benefits of mitigation. By ignoring consumption externalities, the existing integrated assessment models produce an inflated estimate of the optimal level of greenhouse gas emissions today.

The argument has been cast within a standard optimal-growth framework. It is not obvious, however, that this framework should dominate the discussion. The appropriateness of a utilitarian approach in general and the specific version used by the integrated assessment models can be challenged.[19] The issues are beyond the scope of this paper, and we do not pretend to have answers. It can be a problem, however, if an influential discipline makes strong recommendations based on a questionable but seemingly 'objective' set of ethical principles. The problem is compounded if the recommendations are couched in a mathematical formalism that makes it hard for outsiders to follow the analysis.

[19] Economists are aware that there are alternative ethical principles. Nordhaus (2006a, p.8) for instance, points out that "it should be clear that alternative ethical perspectives are possible. Moreover, as I suggest below, alternative perspectives provide vastly different prescriptions about desirable climate change policies." The actual analysis and recommendations, however, are almost invariably based on welfare functions associated with representative-agent models. Sen (1982) is an exception. He suggests that future generations have a right to a non-degraded environment and rejects the 'welfarism' of the standard analysis.

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Appendix: Survey Questions and Results

Question 1: Global warming and other environmental changes threaten the survival of some animal species. According to some studies as many as 25 percent of all species may become extinct before 2100 under current trends. Policy intervention may change this scenario and ensure the survival of the endangered species.

How large a proportion of your stream of current and future income would you be willing to give up in order to ensure that no existing species become extinct?

_____ 0 - 5%
_____ 5 -10%
_____10-20%
_____more than 20%

Question 2: Global warming and other environmental changes threaten the survival of some animal species. According to some studies as many as 25 percent of all species may become extinct before 2100 under current trends. Policy intervention may change this scenario and ensure the survival of the endangered species.

Suppose that the costs of the intervention are shared and that all incomes are reduced by the same percentage. In your view, how large a proportion of current and future incomes should we be willing to give up in order to ensure that no existing species become extinct?

_____ 0 - 5%
_____ 5 - 10%
_____10 -20%
_____more than 20%

Question 3: Global warming and other environmental changes threaten the survival of some animal species. According to some studies as many as 25 percent of all species may become extinct before 2100 under current trends. Policy intervention may change this scenario and ensure the survival of the endangered species.

Suppose that the intervention is financed by reducing the growth rate of the average income and that this reduction is the same for everyone. As an example, if the intervention requires reducing the growth rate of average income from 2% a year to 1.5%, then everyone will experience income growth that is 0.5 percentage point lower than without intervention. In your view, how large a reduction of the growth rate of future incomes should we be willing to accept to ensure that no existing species become extinct?

_____0 percentage points
_____0 - 0.1 percentage points
_____0.1 - 0.3 percentage points
_____0.3 - 1 percentage points
_____more than 1 percentage point

Table 1: Survey Results

	0%	0-5%	5-10%	10-20%	More than 20%
	0 percentage points	0-0.1 percentage points	0.1-0.3 percentage points	0.3-1 percentage points	More than 1 percentage point
Question 1	13.4%	54.2%	24.6%	7.0%	0.7%
Question 2	8.9%	41.7%	40.6%	6.8%	2.1%
Question 3	11.7%	17.8%	30.7%	24.5%	14.7%

Table 2: Growth reductions conssitent with intervals of level reductions for various g and ρ; ($T = \infty$)

Level Reductions	$g - \rho = -1\%$	$g - \rho = -2\%$	$g - \rho = -3\%$	$g - \rho = -4\%$
0%	0% growth reduction	0% growth reduction	0% growth reduction	0% growth reduction
0%-5%	0-0.05% growth reduction	0-0.11% growth reduction	0-0.16% growth reduction	0-0.21% growth reduction
5%-10%	0.05-0.11% growth reduction	0.11-0.22% growth reduction	0.16-0.33% growth reduction	0-0.44% growth reduction
10%-20%	0.11-0.25% growth reduction	0.22-0.5% growth reduction	0.33-0.75% growth reduction	0.44-1% growth reduction
More than 20%	more than 0.25% growth reduction	more than 0.5% growth reduction	more than 0.75% growth reduction	more than 1% growth reduction