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ABSTRACT

The debate surrounding Global Warming and potential policies to curve its consequences has been ever-growing in noise and status. Sir Nicholas Stern's *Review on the Economics of Climate Change* in 2006 stimulated more debate and research with its conclusions of immediate policy action based on cost-benefit techniques; its critics coming from both the mainstream and ecological economic backgrounds. This paper will examine Stern Review's use of discounting in environmental cost-benefit analysis, its critiques, and possible alternatives to analyze the economic understandings of global warming. And, in the end, it will tie together the above economics to the political atmosphere of today.

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"In short, it's all about our great-grandchildren, stupid, and we need the scientists to tell us more about what will happen to them, the sociologists to tell us what they will think about it, and the philosophers to tell us how much we should care what they think. Posing these awkward questions may make economists unpopular, but we are used to that." Paul Klemperer, Edgeworth professor of economics, Oxford University, 2007.

There is considerable agreement among economists of all schools of thought that global warming is a serious problem that requires a policy response, involving both mitigation of the increasing level of CO₂ in the atmosphere and adaptation to the inevitable effects of global warming from present CO₂ levels. The discussion in this paper will focus on the discourse about mitigation policy. Disagreements arise around questions of what the acceptable level of CO₂ is understood to be, and relatedly, what the timetable should be for policies to limit CO₂. While these might seem primarily scientific and ethical questions, the policies require an economic analysis, since addressing global warming will require the harnessing of resources through taxation, reallocation of resources from other projects, and/or rising prices for carbon-based energy, all of which would have immediate and prolonged impacts on the public (there is also the crucial question of how the cost would be distributed among countries and within them—the *Stern Review* argues that the developed countries should bear the largest immediate cost). The dispute among economists revolves around the question of how to determine how much of our present resources should be allocated to alleviating effects of global warming that are not expected to become problematic until considerably into the future. That is, much of the benefit of a strong current policy to alleviate global warming would be felt by the grand, or great-grand, children of those making the investment (because it would prevent the warming from becoming greater than it is already destined to be—we cannot affect the short-run trend).

In the fall of 2006, Sir Nicholas Stern and a lengthy list of co-authors released the *Review on the Economics of Climate Change*, which was commissioned by the British government. The *Stern Review*, as it is generally called, has precipitated a rush of responses by economists both endorsing and challenging its conclusions. In short, the Stern Review employed mainstream cost-benefit techniques to argue that a relatively small but decisive investment in CO₂ mitigation in the present would produce economic benefits in the future that far out-weighed the cost—and that waiting, by contrast, would result in sharply rising costs. This calculation was largely concentrated in one chapter, and surrounded by chapters detailing narratives of the potential disasters from global warming and the difficulties of truly measuring the worth of a preserved environment for human well-being. In all, the Stern Review was a strong rejoinder to arguments (favored by the Bush Administration, among others), that strong limits on CO₂ would be economically disadvantageous. The Review's model demonstrated that strong action in the present was not only scientifically, but also economically, the most advantageous policy.

The problem with this economic analysis, from the point of view of some of its critics, was that the Review arrived at this conclusion via a very particular choice of rates for discounting the future benefits of CO₂ mitigation, with what was viewed as inadequate or fallacious justification for the choices. Other economists using the same basic model, but different assumptions about discounting, had previously arrived at the conclusion that the best course of action resembled a "ramp" of policy responses, starting gradually in the present and increasing in expenditure in the future (and in the process, allowing for a higher projected increase in global temperature). These economists critiqued the Review's choice of coefficients, and thereby its results. While this might seem like nit-picking to anyone not actively involved in these debates, the disagreement is significant both because of the assumptions reflected in the differing coefficients and, obviously most importantly, the policy conclusions—a sharp commitment to limiting CO₂

at once versus a small present investment and the promise of more in the future (it is worth noting the disconnect with real world politics here, as economists at their computers model "optimal" energy policies for the future, assuming that politicians of the future will, in fact, see this as a responsibility they must shoulder).

Still other critiques come from ecological (non-mainstream) economists, who variously argue that calculations of the costs and benefits themselves are fatally flawed by incommensurability among the factors affected (that is, not all are reducible to dollar values), can't reflect the central problem that damages from global warming will be unequally distributed (and likely to have a disproportionate effect on the most vulnerable and poorest global citizens), define well-being narrowly and insufficiently by consumption levels, are unacceptably anthropocentric, and ignore ethical judgments. An additional criticism, from both non-mainstream and, interestingly, some very mainstream economists, is that cost-benefit analysis is at least somewhat beside the point, as the primary reason to address global warming in the present is not to balance mean costs and benefits over time, but to provide an "insurance policy" against the very real, and as yet inadequately understood, possibility of global catastrophe.

In what follows, I will begin with an explanation of the issue of discounting in environmental cost-benefit analysis, the Stern Review's particular use of this technique, and the controversy over the discount rate Stern employed. I will then examine the critiques of the Stern Review by mainstream and ecological economists, and end with my own critique and analysis of economic understandings of global warming.

Consumption-smoothing/Expected Utility: the mainstream model

Finance models routinely use the technique of discounting, in order to determine the relative rates of return of a range of investment options. The discounted present value of an investment calculates the amount of money that, if put in a risk-free interest-bearing account (say, a government bond), would generate the same return over the period as the

promised return from a given investment. The up-front cost of the investment is then compared to the present value of the return, to determine whether the investment is worth the risk involved. Simply put, the question is whether you would be as well or better off by allowing your money to collect compounding interest rather than (say) build a new wing on your factory. The formula for the present value is the sum of expected returns discounted by the compounded interest ($PV = \sum 1/(1+r)^t$). Two important questions that need to be addressed in calculating the present value of an investment are, first, how to determine the expected return from the investment over time; and second, what is the relevant rate of interest to use in discounting this return. It is worth noting that neither the actual return from the investment nor future rates of interest can be known at the time of the investment decision. Economists differ on how stable and predictable capitalism is as an economic system, and therefore on how uncertain the future is. Many mainstream economists view the future in terms of risks, with attendant probabilities, which can be entered into the calculations. At the other end of the spectrum are economists who see the future as fundamentally uncertain (Keynes was in this camp), such that the probability of an future return is simply unknowable. For economists in this second camp, calculations of present values of returns for any but a very short time period are likely to be highly suspect. This distinction is crucial for the debate over addressing global warming as well, as will be discussed below.

Like investment decisions, policies to address global warming involve expenditure in the present, with benefits arriving in the future. But in this model, the benefits take the form of greater future consumption. Basically, the model asks how much consumption we should be willing to forego in the present (largely due to increased carbon costs), in order to lower the negative effects of global warming, and thereby allow more of income to be spend on consumption, in the future. Behind this question are some basic assumptions about the goals of economic policy, which are in turn based on assumptions about human motivations, as well as a very narrow definition of human

well-being. Humans are assumed to derive utility from consumption, where utility is defined as a psychological state of pleasure; and human motivations are assumed to be to maximize the present value of utility for themselves and possibly for other members of their immediate families. Humans, in short, are modeled as individual, rational maximizers, where what is being maximized is utility. Public policy is then judged by whether it facilitates or impedes this goal. Policy intervention into economic choices is controversial, in a mainstream model, because freely fluctuating markets are conceived of as the most effective and efficient way of generating the greatest utility for the greatest number.

However, even the most free-market economists recognize that markets aren't entirely successful in this regard, and while the extent of needed intervention is an object of heated debate, all mainstream economists call for some government involvement in the process of production and allocation—again, with the end goal of utility maximization. The reasons for governmental involvement are two-fold: the need for public goods; and the problem of externalities and market failure. Public goods are goods which are generally desired, but which no one person can purchase for her/himself individually—we can only acquire them by pooling our resources. Clean air would be an example of a public good (public goods are also presented with a more negative story about "free riders"—we need to require everyone to contribute, because we can't prevent anyone from "consuming" the clean air. While this description is really only the flip side of the positive story, it provides a view of public goods as an unfortunate necessity given greedy human nature—while the "pooling of resources" story emphasizes the positive and community-building aspects of public investments). Externalities exist when a private producer can avoid paying some of the costs (or fails to gain some of the benefits) of an economic activity. If a factory, for example, can dump its waste products into a river, and thereby lower its production costs, it will produce more of its product than it would if it had to pay all the costs—some of the costs have been *externalized* onto the community,

in the form of a dirty river, dead fish, undrinkable water, etc. Externalities are a form of market failure, in that without intervention they will result in production at other than the optimum, profit and utility maximizing point. The role of government intervention in this view would be to realign the market forces through regulation, taxes, tradeable permits or some other mechanism, in order to achieve an efficient outcome.

In the case of global warming, the efficiency question is one of consumption-smoothing. Our actions in the present will affect future costs, and therefore future consumption. An efficient policy would be one that acted to assure that future utility isn't being unduly sacrificed to present utility. But note the word "unduly". To get the trade-off right, and calculate the appropriate investment in global warming mitigation in the present, we need to discount future utility/consumption, for two reasons (and employing two attendant discount rates). First, people are assumed to prefer present consumption to future consumption, so the future consumption must be discounted by the disutility from waiting (as the British authors frequently say, we prefer "jam today to jam tomorrow", showing more modest aspirations—and perhaps sweeter teeth—than American economists would be likely to show). This is the discounted rate of time preference. And second, mainstream economists take as a given that the future generations in question will be richer than we are. Capitalist economies are assumed to grow indefinitely. Here an argument is introduced about the marginal disutility of consumption. That is, consumption is always assumed to generate utility, but as we consume more and more, the utility of the last unit of consumption is assumed to be declining. As rational beings, we would of course consume first that which gives us the most utility, then second that which gives us the second most, then the third...and so on. Utility continues to rise, but at a diminished rate. Now since we are less rich now than we will be in the future, the argument goes, the future increase in consumption from our actions to mitigate global warming must be discounted by the lesser utility future generations will get from each additional unit of consumption. Both these justifications for discounting have been

critiqued on a variety of fronts, which will be discussed below. But for the present, let us take these assumptions as given, and examine the construction of the model—and the controversy among mainstream economists—over the discount rates selected and the resulting policy conclusions.

Using this model, we will be spending enough to mitigate global warming in the present when the discounted marginal utility of future consumption is at least as large as the marginal disutility of foregone consumption in the present. The discount rate to determine this calculation is defined as: $r = \delta + \eta(g)$, where δ is the rate of pure time preference (the extent to which we prefer jam today), η is the elasticity of marginal utility (increasing at a declining rate), and g is the growth rate of consumption into the future (measured by growth in GDP). It should be fairly obvious that none of these rates can be known with any certainty (or maybe known at all). While we could conceivably infer δ over the near future by such factors as our willingness to save, in the case of global warming, the future isn't near at all—most of the effects of our efforts in the present will impact generations 100 years or more into the future. So the question here is really "jam today or jam for your great-grandchildren", which a) isn't reflected in any significant way by our current saving strategies (as Stern would also agree), and b) is actually much more a factor of public policy and public goods than the strategies of any one of us.

Eta (η) seems similarly problematic, since the marginal utility function is usually modeled statically—that is, at a moment in time. While it might make sense to posit a declining marginal utility from consumption for a particular individual at a particular moment, it doesn't follow that this result can be extrapolated over time or over individuals. As Amartya Sen has observed (and Adam Smith before him), the level of income necessary for well-being depends in part on the going standard of living. The assumption that future generations will be richer (that $g > 0$) could also be questioned. Certainly if some of the more catastrophic results of global warming do in fact occur (to be discussed more below), there will be a heavy impact on g . But also, the model in

general raises the question of distribution and inequality (as Stern explicitly acknowledges). It makes a difference whether the future is richer and more equal, or richer and less equal (or similarly unequal). Furthermore, do "we" have a uniform view on valuing the present versus valuing the future? Rather than a simplified attribute of human nature, isn't our view of our responsibility to future generations ethical and cultural?

In fact, unlike many of the articles discussing the Stern Review (for example, Quiggen, 2006), the Review acknowledges that we can't know η for future generations. As a result, our choice of discount rate "is essentially a value judgment" (Stern 2007: 52). In addition, the authors recognize the possibility that future generations might actually be poorer, rather than richer, than at present; in that case, g would be less than zero, and the discount rate would be negative, not positive (54). Finally, Stern notes that it is not possible for one discount rate to represent the full array of goods and households affected by global warming:

With many goods and many households there will be many discount rates. For example, if conventional consumption is growing but the environment is deteriorating, then the discount rate for consumption would be positive but for the environment it would be negative. Similarly, if the consumption of one group is rising but another is falling, then the discount rate would be positive for the former but negative for the latter. (60)

The Stern Review's Cost-Benefit Model

Faced with considerable ambiguity over these discount rates, the Stern Review made particular—and unusual for those using this model—choices. Delta (δ) was set at 0.1%—that is, future generations were given nearly the same value as the present. The justification was that it was unethical to devalue our great-grandchildren (the reason δ was slightly above 0 was to account for the slight possibility that our great-grandchildren would in fact not exist, if some event caused the extinction of humans). Eta (η) was set at

1, which again reflected an ethical judgment—an η of 1 gives the result that any proportional change in income/consumption would be equally valued in the future and in the present. Because we were posited to be poorer, any given dollar would have greater marginal utility to us (as a greater percent of our income). One key result of this assumption was that redistribution toward greater equality of income would raise the level of utility—a dollar would have greater utility for a poor person than for a rich person. It must be noted that an η of 1 created a log linear equation (what economists approvingly call a "well-behaved" function), facilitating computation. The value of g was derived from estimated growth rates of the global economy under different assumptions (about the effects of temperature change, among others)—generally between 1.5% and 2%. The outcome is an overall discount rate, r , of between 1.6% and 2.1% (Quiggen: 12).

It bears repeating that this discount rate is the result of ethical choices regarding both the social rate of time discounting and the elasticity of the marginal utility of consumption over generations. Observations of behavior in the present, the Review argues, is an inadequate basis for modeling choices over centuries (Stern 2007:59). In addition, the goods and services which generate utility are broadened from the standard "bundle" to include education, health, and the environment in addition to consumption goods (it isn't clear if non-market consumption goods are incorporated) (32).

Using this model, the Stern Review contrasted the costs of mitigation with the costs of allowing uninterrupted CO₂ increases. The current level of CO₂ in the atmosphere is approximately 430 ppm. The Review considered but doesn't advocate for stabilizing CO₂ at around this level (which would require quite drastic measures). Rather, it focused on a target goal for CO₂ at 550 ppm (resulting in an estimated global temperature increase of 2-3 degrees centigrade) (2006:iii). To achieve this goal, the Review estimated that it would be necessary for CO₂ emissions to peak in the next ten to twenty years, then fall at a rate of at least 1-3% a year (xi). Using their selected discount rates, they calculated the costs of this level of mitigation at an average of 1% of GDP per

year by 2050 (xiii). They contrasted this cost with the results of "business as usual" (no attempt to mitigate CO₂ levels), which are estimated to result in a 5-6 degree centigrade increase in temperature, and cause a 5-20% decrease in consumption per head globally—with the damage disproportionately borne by people in the poor regions of the world (x) (the wide range of damage estimates reflects the continuing uncertainty about the dynamics of feedback effects which could considerably exacerbate global warming). In short, by the Stern Review's calculations, "the benefits of strong, early action considerably outweigh the costs" (ii).

A Ramp, Not a Leap: the Nordhaus critique

The model which was employed by the Stern Review had been used by other economists, who arrived at different conclusions. More than a decade earlier, environmental economists William Nordhaus and William R. Cline had each provided estimates of the costs and benefits of mitigation. Cline had used a discount rate similar to the Review's, while Nordhaus had used a considerably higher level of $\delta=3$, and an overall discount rate, r , of 4% (Quiggen 2006:14). As a result, while Cline's calculations supported early action to mitigate CO₂, Nordhaus's model suggested a gradual "ramp" of increasing mitigation.

In his critical evaluation of the Stern Review, Nordhaus defends his view. Observed data suggest that we discount the future more than the 0.1% that Stern assumed, according to Nordhaus (although he distinguishes between the near future, which he discounts at 3%, and the distant future, with the rate of time preference gradually declining to 1% by 300 years, presumably on the assumption that we don't have as strong a preference between gains in, say 250 years compared to gains in 300 years) (13). Because of our preference for present over future consumption, and because future generations will be more affluent, in Nordhaus' model it is more efficient to increase mitigation gradually, for two reasons. First, in the present, the most productive

strategy is investment in the research and development of low-emissions technologies. Second, and relatedly, this productive investment will lead to a more affluent society, better able to afford stringent mitigation policies:

In a world where capital is productive, the highest-return investments are primarily in tangible, technological, and human capital, including research and development in low-carbon-emissions technologies. As societies become richer in the coming decades, it becomes efficient to shift investments toward policies that intensify the pace of emissions reductions and otherwise slow GHG emissions. The exact mix and timing of emissions reductions depends upon details of costs, damages, and the extent to which climate change and damages are irreversible (3).

It should be noted, though, that the "climate-policy ramp" which Nordhaus envisions would be fairly steep—the estimates from his preferred model of efficient mitigation prescribe an emissions reduction of 6% at the present, 14% in 2050, and 25% in 2100, with a projected temperature increase over the century of 1.8 degrees centigrade (15).

Nordhaus doesn't reject the Review's emphasis on the importance of intergenerational equity; rather, he suggests that other strategies (such as redistribution in the present, or stockpiling essential commodities for the future) would equally satisfy ethical values. Reflecting the on-going dispute among economists and environmentalists about the definition of sustainability, Nordhaus seems to endorse what Harris terms "weak sustainability"—under which to satisfy sustainability criteria "each generation should leave at least as much total societal capital (tangible, human, and technological) as it inherited," a standard that "would admit a wide array of social discount rates" (9). This view of sustainability, and hence of mitigation policy, has been critiqued by ecological economists because it aggregates incommensurable values, as will be discussed below. In all, Nordhaus takes sharp exception to what he terms the "radical revision of the economics of climate change" inherent in the Stern Review's choice of discount rates; yet he also allows that the Review's "results are fundamentally correct in sign if not in

size" (4). In Nordhaus's view, as in Stern's, there is no economic justification for avoiding strong government policies to effect a stabilization of greenhouse gases, including increasing carbon prices (5); the question is only (although certainly not trivially) one of timing.

Kenneth Arrow tends to share Nordhaus' skepticism about the Review's choices for δ (which he terms ρ) and η . However, his review of climate science suggests that the high-climate scenario, with a GDP loss from BAU at 20%, is the appropriate variable to use for g (in this he differs from Nordhaus by his incorporation of risk into the calculation; without a risk premium, the g is 13.8%, which is the figure Nordhaus uses to dismiss Stern's calculations). With these figures, and an η of 2 (which Arrow argues is more compatible with evidence that Stern's $\eta=1$), Arrow calculates that Stern's conclusion that immediate mitigation is justifiable is valid for any social rate of time discounting (Stern's δ , Arrow's ρ) less than 8.5%—a figure far greater than any researcher has suggested (Arrow 2007:4-5). By using the high-climate projection, and including a risk premium, Arrow mirrors in many respects the arguments of Weitzman (below), in essence viewing immediate steps toward mitigation as insurance against disaster:

I agree that both futurity and uncertainty require significant discounting. However, even with that, I believe the fundamental conclusion of Stern is justified: we are much better off to act to reduce CO2 emissions substantially than to suffer and risk the consequences of failing to meet this challenge" (Arrow 2007:1).

The Incommensurability Critique

In calculating the costs and benefits of mitigating global warming in the present, compared to a policy of "business as usual" or Nordhaus policy "ramp", as we have seen, both Nordhaus and the Stern Review rely upon aggregate monetary measures of the costs at present and the (discounted) benefits—in the form of lowered costs—in the future. In order to do this, the analyses must assume that values lost and values gained are

interchangeable, reflecting a particular view of sustainability—Solow (or "weak") sustainability (Harris 2006), in which the responsibility to future generations is to leave them roughly the same productive capacity that we possess. Productive capacity is measured by the capital stock; manufactured capital, natural capital, and human capital (and in some analyses social capital) are assumed to be substitutable, at least to a large degree. So, in this view, exhaustion of a natural resource can be compensated for by technological development and loss of a species by a rise in human capital.

In the case of the Stern Review, our responsibilities to future generations are generalized into three categories: health, environment, and income/consumption. Because they are treated as commensurate in the cost/benefit analysis, loss in one (or even two) of the categories could be compensated by increases in the third. Since it is assumed that income will grow over time, the results can be read, in ecological economist Clive Spash's critique, as resolving any ethical concerns, since "more consumption makes everything better" (Spash 2007:4). Additionally, within a given time period, some populations will be affected more than others by global warming—in fact, at least initially, global warming's effects overall may raise GDP in some cold climates, while wreaking havoc in low lying areas around the equator. Aggregation and commensurability would mean that advantages to one area would, in effect, cancel out damages to another. Stern does weight consumption in poor countries more heavily, in an attempt to address the inequity, but the problem remains of balancing a rise in consumption in one area against destruction in another (Spash 2007:5).

Ecological economists have long challenged this assumption of commensurability, noting that natural capital provides ecological services that are complex, crucial, and not easily replaceable by manufactured capital. In addition, many environmentalists argue that the natural environment is intrinsically valuable. They reject utilitarian calculations of values, which reduce all types of valuation to preferences, and all preferences to monetary values. Environmental scientist Sarah Trainor, for example,

categorizes values into ten "realms", including aesthetic, cultural, economic, ecosystem, religious, and scientific (Trainor 2006:12), that are fundamentally incommensurate. She calls for "collaborative, discursive processes" that "explicitly acknowledge and consider each realm in its own terms, rather than...rely solely on an assessment that views all values through one lens" (Trainor 2006:21). Geographer Eric Neumayer suggests that the danger of non-substitutable loss of natural capital (that is, loss that can't be compensated for by an increase in consumption) would mean that policy judgments need to be based on an assertion of the rights of future generations, rather than utility calculations: "This would call for action if climate change violates fundamental and inalienable rights of future generations" (Neumayer 2007:3). Neumayer also notes that even within a utilitarian framework, non-substitutable losses of natural capital would lower the utility of future generations to an extent that could not be compensated for by increased consumption. Thus even within the standard analysis, incommensurability would require immediate action on global warming (3). To this could be added the rights of non-human species, which could certainly be argued to be incommensurable with human values.

Accounting for inequitable distribution of costs and benefits

The Stern Review demonstrates an acute awareness of the unequal distribution of both the actions that caused global warming and the predicted effects. It calls upon the developed countries to subsidize policies to help the developing world to both mitigate and adapt to the effects of global warming: "The poorest developing countries will be hit earliest and hardest by climate change, even though they have contributed little to causing the problem...The international community has an obligation to support them in adapting to climate change" (2007:xxvi). The Review attempts to avoid an impression of meddling, stating that "It is for the developing countries themselves to determine their approach to adaptation in the context of their own circumstances and aspirations," although it promptly adds, "Rapid growth and development will enhance countries'

ability to adapt" (xxvi). It notes that the costs of adaptation will run in the "tens of billions of dollars", and calls upon the developed countries to honor their aid commitments and to invest in "global public goods" such as climate models and new crop development that would assist the adaptation process (xxvi).

The Review has in general received strong praise for its direct and forthright acknowledgment of inequality and responsibility. Still, in its calculations, even though effects on poor countries are weighted to give them more emphasis, the problem of ascribing a monetary value to the potential destruction of poor peoples' ways of life remain. Spash notes that the loss of value through displacement in poor countries is calculated as three times per capita income. He asks "Why? How has someone decided this? What do we do about the fact that...millions live on \$2 a day or less? Is a couple of thousand dollars meant to compensate forced relocation?" (Spash 2007:4). He also notes that this value is simply being used in a cost-benefit analysis; it does not imply that the poor would, in fact, be compensated even this much.

In addition, there is reason to suppose that climate change will impact groups differently, by income as well as geography, within the developed countries as well. If it wasn't clear before, Hurricane Katrina certainly illuminated the different abilities to survive and recover from a natural disaster by class, by race, and by gender. An aggregative analysis conceals such problems, and may lead to complacency (GDP is growing) in the face of rising inequality. The Review in fact dedicates much of its nearly 700 pages to precisely this matter, documenting the inequality in both the damages from global warming (between and within countries), and in the resources to address the problem. Still, its inclusion of a global cost/benefit calculus leaves it open to critique.

The Emphasis on Growth

Both the Review and its mainstream critics accept the desirability of economic growth. Increases in GDP are equated with increased human well-being (more on this below), and no suggestion is made that there might be limits to growth. Spash points out that, despite the Review's attempt to insert ethical and redistributive concerns into its calculations, in the end its model defines a successful policy as one that increases income and consumption. Spash quotes the Stern Review's executive summary, "Tackling climate change is the pro-growth strategy for the longer term" (2007:viii), and asks, "why is the problem being framed like this, as 'the pro-growth strategy'?" (Spash 2007:5).

Citing Nicholas Georgescu-Roegen, one of the first economists to engage in environmental analysis, Spash argues that the success or failure of environmental policies can't be judged by changes in GDP. Ecological economists often call for the construction of a "steady-state" economics, in which the emphasis is on the quality, rather than the quantity of production. But Spash points out that even a zero rate of growth of the developed countries could lead to an exhaustion of world resources (Spash 2007:6). Further, GDP increases could, in fact, indicate a decrease in well-being, or desperate measures to prevent a decrease, as plausibly as an increase. GDP is merely a measure of market activity, not well-being (Spash 2007:6). And while the Stern Review argues that "Rapid growth and development will enhance (poor) countries' ability to adapt" (2007:xxvi), Spash responds that poverty needs to be addressed directly, rather than through "hopes of trickle down from blanket increases in material throughput." (6) He concludes by pointing out that the emphasis on economic growth in the Stern Review violates its own stated concern for ethical, distributional, and precautionary values. The consumption smoothing/expected utility approach privileges narrow and simplistic understandings of economic gain over more complex measures of well-being. In Spash's scathing critical terms: "Rather than asking why humanity should expect a positive rate of

return on climate disaster prevention, the only question is how large is the return?"
(Spash 2007: 7).

Broader Critiques: measures of well-being, and insurance against catastrophe

These comments of Spash's lead into two areas of broader and more fundamental critiques of the mainstream analysis of global warming mitigation: first, that the level of income and consumption is not an adequate measure of well-being; and second, that mitigation shouldn't be evaluated as a means of consumption-smoothing but rather as an insurance measure against the possibility of a global climate disaster. The first set of critiques comes largely from outside mainstream economics, and incorporates arguments from ecological, political, and feminist economics, as well as the capabilities approach to well-being introduced by Amartya Sen. The second critique is made not only by heterodox economists, but also, interestingly, by one highly influential and conservative mainstream economist.

Human Well-being

"I don't need money, I want the river's color back"

Silas Matkime, son of the Waa Valley Chief, Irian Jaya, Indonesia

Business Week, Nov. 20, 1995 (quoted in Beneria 2003: 86)

While the debate over discount rates cannot avoid reference to moral and ethical considerations, the focus of the calculations, as discussed above, is neoclassical utilitarian analysis, in which individual preferences, measured by GDP growth as a proxy for consumption, are the metric for well-being. Obvious limitations on this approach have been discussed above, including issues of distribution and the importance of examining the content, and not just the extent, of GDP growth. But in addition, there is an extensive

literature on alternative measures of well-being which is sharply critical of the standard economic reliance upon GDP.

Perhaps the best known alternative is the capabilities approach developed by Amartya Sen, which has fostered a large body of scholarship. In fact, the Stern Review cites Sen frequently, and dedicates a section early in the book to his capabilities approach. The Review basically finesses the differences between the "welfarist" and capabilities approach, however, asserting that "the consequences on which most of these notions would focus for each generation often have strong similarities: above all, with respect to the attention they pay to consumption, education, health and the environment." (Stern 2007:32).

Sen's critique of an over-reliance upon income as a measure of well-being is very relevant to the debate over global warming mitigation. Well-being, in Sen's analysis, is defined by the ability to "lead the kind of life (one) has reason to value" (Sen 1999:87), which Sen terms one's "capabilities." While low income may well affect one's capabilities, the two are not necessarily correlated. In Sen's words, "The instrumental relation between low income and low capability is *variable* between different communities and even between different families and different individuals (the impact of income on capabilities is contingent and conditional)" (Sen 1999:88). He offers a number of examples of this variability, of which two are of particular relevance to the discussion of global warming. First, Sen notes that the translation of income into capabilities would be affected by the circumstances in which a person finds her/himself, including geographic, climatic, and epidemiological factors over which the person has little or no control (88). A change in climate that, for example, destroys an ecosystem and with it a traditional way of life that depended upon it (for example by destroying a fishing ground) would have effects on the capabilities of that population, which might be independent from their level of income. As in the quote that begins this section, people may well value their lives and their natural surroundings for intrinsic reasons.

Additionally, the danger that global warming may lead to epidemics raises the possibility that future generations may have more income, but worse health. Clearly their capabilities would be impacted.

Second, following in the tradition of Adam Smith and other classical economists, Sen notes that an acceptable standard of living is a social construction, so that one's relative level of income, rather than absolute, affects one's capabilities: "Being relatively poor in a rich country can be a great capability handicap, even when one's absolute income is high in terms of world standards" (89). An historically-specific level of income is needed in order to participate actively in the community (89) -- for example, homeless people in the United States find it very difficult to obtain jobs if they cannot write a phone number on the job application. The implication of this observation is that it is impossible to infer the relationship between income and the marginal utility of consumption of a population in the future, as the standard model does with the variable η .

Third, Sen's capabilities approach puts a great deal of emphasis on individuals' agency in choosing how to live their lives. Thus, he distinguishes "functionings" ("the various things a person may value doing or being") (75) from the "substantive freedom—the capabilities—to choose a life one has reason to value" (74). Capabilities require that people be enabled to choose among "the alternative combinations of functionings that are feasible...to achieve" (75). This emphasis on agency and choice casts a different light on our obligations to our great-grandchildren. We may seriously impede their well-being if, by failing to act swiftly on global warming, we sharply limit their choices of lives they "have reason to value." They may have more income, but we may have permanently destroyed their abilities to get "the river's color back." The capabilities view would not be compatible with the Solow sustainability view of aggregated capital. Because we cannot ask future generations what choices they would prefer to make, concern for their well-being would require us to keep as many options open as possible, which implies

damaging natural capital as little as possible. In the words of Oxford economist Paul Klemperer,

So do we know, for example, how our great-grandchildren will feel about the likely extinction of several million of the world's species? Maybe they will feel that, despite their fabulous wealth, and despite being awash with mobile phones and super-high-resolution televisions, they have actually experienced a catastrophe (Klemperer 2007:15)

CO₂ Mitigation as Catastrophe Insurance

One very interesting aspect of the discussion of global warming policy centers on the distinction between risk and uncertainty. Risks involve probabilities of occurrence which can be calculated with a degree of uncertainty, and therefore can be used as data in constructing a cost-benefit optimization model. Uncertainty about events implies that we currently lack (or permanently lack) information that would make it possible to calculate probabilities (this distinction between risk and uncertainty is sometimes referred to as "weak" versus "strong" uncertainty). This distinction was very important to the arguments of John Maynard Keynes in his discussion of investment and the importance of government involvement in smoothing instabilities in capitalist economies: investment (that is expenditures on capital equipment) involve gambles on an unknown and unknowable future, in which returns to the investment cannot be predicted with any degree of certainty.

Authors emphasizing the role of uncertainty in environmental policy point out that the effects of global warming are both highly uncertain and potentially catastrophic (Toman 2006:367; Dietz 2007:175; Weitzman 2007:3). Given this uncertainty, they suggest, it would be better to view immediate CO₂ mitigation as insurance against future disaster, than as a means of consumption-smoothing. In the word of environmental economist Simon Dietz,

We must entertain the prospect of huge changes in physical and human geography, even if they make the practices of economic analysis and policy making more difficult. Such changes could have tremendous impacts on the international economy, in particular as a result of the distribution of impacts between North and South and the potential for global security threats through migration and violent conflict. While it is difficult to quantitatively determine the harm that each of these individual problems might cause, there is certainly basis for acting to prevent or minimize climate change. While such pursuits may be costly, they must be viewed as a form of global insurance –taking costs upon ourselves in the present to avoid a potentially disastrous future."(Dietz 2007:174). (Dietz worked as a policy analyst on the Stern Review)

Environmental economists Gary W. Yohe and Richard S.J. Tol agree, critiquing the Stern Review's emphasis on cost/benefit analysis rather than risk-management. Cost/benefit analysis, they argue, isn't equipped to handle the degree of uncertainty about the effects of global warming. As a result, the Review is vulnerable to critics of early mitigation, who can critique their assumptions about the level of damage (according to Yohe and Tol, Stern tended to select high estimates of damage) as well as their choice of discount rates. A risk-management approach would be more effective, because the existence of even one intolerable possible consequence of climate change would justify action:

As soon as it is established that one of those risks is possible (and even most skeptics must acknowledge that the *Stern Review* has accomplished this task), then clearly it can be said that there is an established need for climate policy (Yohe and Tol 2007:41).

Economist Martin L. Weitzman, writing about the Stern Review in the *Journal of Economic Literature* begins by critiquing the Review's choices of discount rates, suggesting that low rates were selected not on the basis of economic evidence, but in order to achieve the Review's desired policy recommendation of immediate action to mitigate CO₂. While he critiques the assumptions by which Stern arrives at a low total discount rate (in particular being fairly scornful of "*a priori* philosopher-king ethical judgments" substituting for revealed preferences) (Weitzman 2007:13), he in fact offers alternative arguments which somewhat endorse the level, if not the logic, of Stern's r.

But more importantly, Weitzman argues that "there was never any deep economic rationale in the first place for damages from greenhouse-gas warming being modeled as entering utility functions through the particular reduced-form route of being a pure production externality...It was more due to an historical accident..." (Weitzman 2007:14)

For Weitzman, it is the possibility of a suddenly accelerated global warming that should be central to the analysis; and its effects would be primarily on g (growth in GDP as a proxy for growth in consumption). The possibility of "highly-unlikely poorly-understood threshold-crossing disasters associated with abrupt large-scale irreversible changes in the climate system" (Weitzman 2007:17) results in a probability distribution of future consumption growth with a thin right tail (high consumption) and a thick left tail (low consumption). In other words, the danger of future generations being worse off through catastrophe far outweighs the possibility that they will be better off than we predict. To this Weitzman adds that alternatives to CO₂ abatement through investment in GDP growth in the present won't solve this problem, challenging the weak sustainability argument:

If the definition of consumption is broadened (as it should be) to include non-market enjoyment of the natural environment—like habitats, ecosystems, and species—it is difficult to imagine what the compensating investments are for which we should be now saving more as an alternative that might substitute for holding down [the temperature increase] directly."(18).

It might be inferred from this argument that substantial CO₂ mitigation should begin immediately. But Weitzman steps back from the Stern Review's call for a sharp increase in the present, seeking a "middle course", which "combines the gradualist climate-policy ramp of ever-tighter GHG reductions" with "putting serious research dollars into early detection of rare disasters" and "a major public dialogue about contingency planning for worst-case scenarios" (25). If these "serious research dollars" demonstrate that early detection isn't feasible, or that warming is irreversible, then

Weitzman would endorse the Stern Review's conclusion. At present, in his view, it is premature and unnecessary: "We can always come back in ten or twenty years time and declare all-out war on global-warming emissions then—if we then think it is the best option among a better-studied reasonably-considered portfolio of possible options" (26).

Seizing the Moment: Politics and Economic Rationality

One striking aspect of the mainstream discussions of global warming policy is their exclusive focus on what is perceived to be economically efficient, with no reference to the dynamics of the political process. This comes, I suppose from the standard positivist economics rationale that the role of the economist is to describe, not prescribe, a view which has been critiqued repeatedly by heterodox economists. In this particular case, the absence of reference to the political dynamic is especially striking, since in fact the economists all agree that future generations are endangered by our inaction, and that steps must be taken, whether gradually or quickly, to decrease CO₂ emissions.

Consideration of the political realities makes Nordhaus and Weitzman's policy of a gradually increase in mitigation over decades seem particularly problematic. Policies to decrease CO₂ emissions will require increases in carbon taxes and/or fees, the establishment of complicated international trading schemes and regulations, and changes in "business as usual" at levels from the individual to the global. Costs will rise, habitual ways of doing things will be challenged, consumption patterns will have to be changed, and global wealth redistributed toward poorer countries. While it may be a stretch to call these changes "sacrifices," there is no doubt that much of the public in rich countries will find themselves inconvenienced; and regimes in developing countries will have to retool development paths to which they have become committed. It will take a major leap of political will to put these policies in place. It would be all too easy, with the "ramping" policy, for future policy makers to respond to public annoyance, or the pressures from affected interest groups, and back away from the mandate to increase mitigation

(particularly since the benefits of mitigation in the present won't be visible within the lifetimes of those affected by the policies). Weitzman's blithe statement that we "can always come back in ten or twenty years time" and increase the rate of mitigation assumes that the political will is always swayed by the scientific evidence. If that were true, CO₂ mitigation would be long underway.

Given the climate-related challenges of the past two years—including Hurricane Katrina; drought and heat waves in the United States, Europe and India; and the summer 2007 flooding in Britain, India, and Bangladesh—and the success of the film, *An Inconvenient Truth* -- public opinion seems open to policies addressing global warming. It would be, in my opinion, advisable to seize this political moment to put in place as strong a policy of mitigation as is possible. If the political will does, in fact, hold, we can always "ramp up" from there.

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