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Discounting the Distant Future and Climate Change

Standard methods of benefit-cost analysis (BCA) discount future costs and benefits to make comparisons of alternatives in terms of their *net present values*—typically expressed in dollars.[1] (Up-front costs are included in the calculations as well.) Such methods are problematic when applied to public policy choices in which costs and benefits are uncertain, involve large-scale—and possibly irreversible—impacts; and extend several decades—or even centuries—into the future. Global climate change and the storage of nuclear wastes are two examples of public policies whose choices (including the choice of doing nothing)—clearly meet these criteria. In this paper, I shall refer to projects under consideration to address such large-scale, intergenerational policies as *large-scale, distant-future* (LDF) projects.

The choice of a discount rate is a key decision point for analyzing LDF projects, including climate change: ". . . among all the variables, the discount rate has the largest impact on current policy for global warming" (Nordhaus/RFF 1999, 146). This is so for two primary reasons: First, in the standard approach to discounting, the present value of a stream of future benefits or costs diminishes as the discount rate increases; and second, the present value of the cumulative benefits or costs beyond the 40th year, say, typically contributes little to the total analysis under conventional BCA methods.

Questions regarding the appropriate level of the discount rate cannot be easily separated from the larger question of the validity of the BCA method itself. The literature surveyed in this paper suggests that most economists regard BCA analysis as a useful tool in assessing LDF projects, but are divided as to whether BCA findings should be decisive in choosing a course of action to respond to the underlying public policy issues of such import. And among those economists willing to use BCA as a meaningful tool for assessing such projects, views on how to select a credible *social discount rate* (SDR) tend to cluster around one of two primary approaches—an investment approach or a savings approach, in which savings is viewed as foregone consumption.

The word "social" indicates that LDF projects typically are matters of substantial and widespread public concern, as well as the likely involvement of public officials in setting policies and regulations, and funding and/or implementing programs. Thus, I focus here on examining the practice of discounting as it affects estimating the *total* costs and benefits to society (i.e., both public sector and private sector) of proposed LDF projects.

This paper focuses on identifying, describing, and critiquing a number of key conceptual and ethical issues at stake in the use of discounting within BCA for LDF projects.

I draw primarily upon a collection of essays by 20 distinguished economists convened in November 1996 by the Washington, D.C. think tank, Resources for the Future, to examine the effects of discounting on intergenerational equity (Porto and Weyant, 1999, heretofore referred to as the "RFF collection" or "RFF" in citations). Writing ten years later, Paul Portney, president of RFF at the time of the 1996 conference, acknowledged that consensus among the group on key findings diminished as time horizons for LDF projects increased:

> . . . the authors were nearly unanimous in recommending the use of standard procedures for evaluating projects with time frames of forty years or less. Within the scope of this of this relatively short period of time, they generally embraced discounting benefits and costs to make present value comparisons. What's more, they tended to think that the discount rate should reflect the opportunity cost of capital. *Beyond the forty-year mark, however, discomfort set in . . .* (Portney 2006, 36; emphasis added).

Another voice on discounting LDF projects included here is that of Sir Nicholas Stern, former Chief Economist of the World Bank, and primary author of the recently-released *Stern*

Review on the Economics of Climate Change (Stern 2007). The *Stern Review* is arguably the most recent and comprehensive economic assessment of future global climate change available. Two of its key findings:

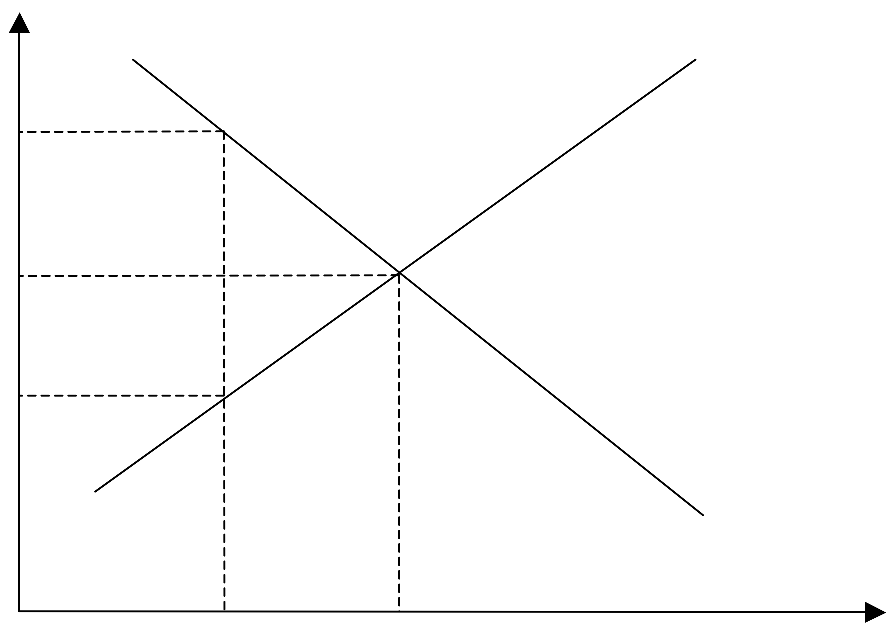
> In summary, analyses that take into account the full ranges of both impacts and possible outcomes—that is, that employ the basic economics of risk—suggest that BAU [business as usual] climate change will reduce [global] welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20% (Stern 2007, Executive Summary, page x).
>
> Emissions have been, and continue to be, driven by economic growth; yet stabilizations of greenhouse-gas concentrations in the atmosphere is feasible and consistent with continued growth. . . . The Review estimates the annual costs of stabilization at 500-550 CO_2e to be around 1% of [global] GDP by 2050 – a level that is significant but manageable. (ibid., pp xi-xii).

Thus, the *Stern Review* claims that a decision in favor of substantial—and costly—action now and the near future would have a significantly positive benefit-cost ratio.

This paper is in three sections, including a brief conclusion. The first section examines two basic approaches for establishing a credible *social discount rate* (SDR) for LDF projects, whose origins go back to the classical loanable funds theory of interest. The second section highlights arguments against using BCA (with discounting) as a decision-making framework for LDF projects, while affirming its usefulness as a tool. In light of the most recent scientific information about climate change, the final section critiques the view held by many authors cited that a sequential, "go-slow," approach to climate change abatement is warranted, due to uncertainties and substantial opportunity costs of taking action now.

I: ESTABLISHING A SOCIAL DISCOUNT RATE FOR LDF PROJECTS

Here I examine two very different approaches to selecting a social discount rate (SDR) for large-scale, distant-future (LDF) projects. These two approaches have their roots in the *loanable funds theory of interest* as explicated by the classical theory of interest and illustrated in Figure 1 (Young 2002, 2-5). Here, savings and investment are functions of the interest rate that may be interpreted, respectively, as the *supply* of loanable funds (via savings, S) and the *demand* for such funds (via investment, I). (See, for example, Peterson and Estenson 1996, 84-86.) Under conditions of perfect competition, the supply (S) and the demand (I) for loanable funds reaches equilibrium at point E for some equilibrium rate of interest r^* and some quantity of loanable funds which may be designated equivalently as $S^* = I^*$. Otherwise said, the market for loanable funds—is *cleared* at the interest rate r^*. A commonly used measure of the demand for loanable funds (I) is the market price of bonds as a function of the interest rate.[2] (Heretofore, I refer more simply to the market for loanable funds as the *market for capital*.)



However, perfectly competitive conditions do not obtain in actual markets for capital—due to such distortions as taxation, expected inflation, monopolies, lack of complete information, and other externalities. Consequently, as shown in Figure 1, market conditions for loanable funds typically are not at optimal equilibrium point E. The differences between the supply and demand for such funds is the origin of the two different approaches to arrive at a credible social discount rate. The candidates are the *social opportunity cost* (SOC) for capital and the *social rate of time preference* (SRTP) for capital.

The *social opportunity cost* (SOC) for capital is the simpler of the two and is derived from the perspective of investment. One interpretation for the demand for loanable funds (investment, I) is the opportunity cost of capital. The SOC rate of return is the rate that reduces the net present value of the best alternative private use of funds to zero. Thus, the SOC discount rate is primarily related to private capital markets (Young 2002, ibid.)

The *social rate of time preference* for capital is derived from the perspective of savings and is conceptually more complex. First, interpreting savings as foregone consumption yields a definition of the *rate of pure time preference* for capital as the interest rate $\boldsymbol{\rho}$ at which people are willing to postpone [more precisely, are indifferent to] consumption of C amount now for consumption $C(1+\boldsymbol{\rho})$ in the next time period. The social rate of time preference (SRTP) is this component $\boldsymbol{\rho}$, plus the product of two additional factors explained below, and is typically expressed as the formula $\mathbf{SRTP} = \boldsymbol{\rho} + \boldsymbol{\theta}\mathbf{g}$, where

$\boldsymbol{\rho}$ = the rate of pure time preference,
$\boldsymbol{\theta}$ = the absolute value of the elasticity of marginal utility, and
$\mathbf{g}$ = the growth rate of per capita consumption.

(See, for example, (Cline/RFF 1999, 132) and, using different notation, (Stern 2007, 46).)

The first factor, **θ,** is grounded in the *principle of decreasing marginal utility*: i.e., the more we have of something, the less utility, or value, we place on having an incremental unit of it. Thus, if θ = 1.5, (the mid-point of the interval [1,2] for **θ** from consensus in the research literature), then "a 10% raise in consumption causes the incremental value of an extra unit of consumption to fall by 15%" (Cline/RFF 1999, 133). The second factor, **g**, is the average rate of growth of per capita consumption. Often, the average growth rate of GDP is taken as the measure of **g**.

In sum, the on-going debate over the appropriate social discount rate for LDF projects is in terms of SOC vs. SRTP and centers on three elements: (i) the "tilt" given to the investment or savings (as foregone consumption) perspective; (ii) variations in interpreting key concepts and variables; and (iii) different assessments of the long-term projections of the direction of key variables and their associated quantitative measures. Next, I highlight positions regarding the appropriate social discount rate of two economists supporting the SRTP (savings, or foregone consumption) view, and two economists favoring the SOC (investment) view.

<u>SRTP perspective</u>. William Cline and Sir Nicholas Stern both defend this view and both set the rate of pure time preference **ρ = 0** by stating, in effect, "It's the right thing to do." For example, "Individually, such discounting is a recipe for living like a prince in youth, a pauper in old age. For those who take decisions on behalf of society, it is irresponsible." (Cline/RFF 1999, 132). Both authors cite the ethical statement (but not the full argument) made nearly 80 years by one of the pioneers in discount analysis, Frank Ramsey, who described pure time preference as "ethically indefensible and [arising] merely from the weakness of the imagination" (Ramsey 1928, 543), cited in (Stern 2007, 31). In Cline's cited article (only 10 pages long), he does not provide a more detailed ethical argument to defend setting **ρ = 0**. In the *Stern Review*

(over 700 pages), however, Stern discusses the ethical dimensions of climate change in detail (see Chapter 2) by tempering the standard approach of welfare economics with the importance of individual human rights. In doing so, the report draws upon the work of Amartya Sen and others on human capabilities and freedoms.

Cline goes on to use the mid-range estimate of $\boldsymbol{\theta = 1.5}$ as described above and his "best guess" for **g** as "no more than 1% per year" over the next 200-300 years (ibid.). He defends this modest growth rate by noting that, "So far, technological change has come to the rescue of the exhaustion of fertile soils and the diminishing returns to additional capital per worker"—implying that the latter trends will eventually dampen the net impact of technological change on **g** in the future.

In sum, then, Cline argues for equating the social discount rate with the SRTP and comes up with a long-term estimate of $\mathbf{SRTP} = \boldsymbol{\rho + \theta g} = 0 + 1.5*1\% = 1.5\%$. Cline defends his estimate in comparison to typical market rates of 6-8% as follows: First, such market rates are really the sum of SOC + w, where w represents a "wedge" of market distortions for capital mentioned earlier. Second, he argues that the long-term real market rate for the next century could be closer to 3%, due to slowing in technological innovation and diminishing returns to capital. If the "wedge" term is as much as half of the real long-term interest rate of 3%, then his SRTP = 1.5% is arguably quite close to "net SOC". [On the surface of it, I find this argument less than persuasive. Cline provides no evidence that technological innovation is slowing. More compelling, I think, is his observation that soil fertility is declining—a marker for increased environmental degradation that arguably may dampen, or even reverse, the assumption of average positive rates of growth in real GDP per capita in the future—i.e., that $\mathbf{g > 0}$.]

Stern's analysis expresses the discount rate exactly in terms of the SRTP formula, but the discount rate is not fixed. Rather, the discount rate is determined from a given growth path within an underlying framework of welfare economics. The details are technical and lengthy (Stern 2007, 43-52).

SOC view. In contrast to Cline, Alan Manne avoids attempting to justify a specific discount rate for the distant future. "The lower the discount rate, the greater becomes the sensitivity of near-future decisions to distant-future parameters that are inherently uncertain" (Manne/RFF 1999, 112). Because of this huge uncertainty, Manne argues for a *sequential approach* to decision-making and advocates using market rates of discount [i.e., SOC rates of return] as the appropriate social discount rate in the near-term. His argument is based upon the tautology that SOC = SRTP at the equilibrium point E in Figure 1. He writes: "Along a time path that is economically efficient, the market rate [of interest] will equal the marginal productivity of capital and also the rate of discount on consumption goods" (ibid.). However, his argument does not support the choice of SOC over SRTP when economic efficiency is absent. Manne also distances himself from Cline's approach by characterizing his own approach as "descriptive" and Cline's as "prescriptive."

William Nordhaus constructively addressing the sterile debate over prescriptive vs. descriptive approaches to discount rates by using computer models to conduct sensitivity analyses on key parameters. He argues that setting a figure for the "pure" [i.e., undistorted] rate of social time preference is equivalent to setting a social savings rate (Nordhaus/RFF 1999; 151, 155). From Figure 1, an increase in the savings rate—i.e., an increase in the quantity of savings for a given rate of interest—would push the savings line to the right. This movement would push the equilibrium point down and to the right, thus increasing the level of investment and lowering interest rates. Nordhaus models the effects on climate change and economics by increasing the savings rate—which has the same effect as lowering the pure rate of social time preference from 3% to 0% or 1%. He concludes from these sensitivity analyses that a policy of increasing the savings rate "is extremely costly" and "has little effect on long-term warming" (ibid., 155)

II. BENEFIT-COST ANALYSIS: FRAMEWORK OR TOOL IN EVALUATING LDF PROJECTS?

Here we shift from considering the proper level of discount rate (or the proper way of conceptualizing it) to the broader question of how—if at all—benefit-cost analysis (BCA), including discounting, can be credibly employed in analyzing the impacts of large-scale, distant-future (LDF) projects. In this section we examine two principal viewpoints: (i) BCA is totally inappropriate as a tool for analyzing the economics of climate change; and (ii) BCA can be a useful tool, but is not suitable as an overarching framework for decision-making. (A third possibility is to view BCA in unmodified form as suitable as both an analytic tool and *as a decision framework* for evaluating LDF projects. The 2004 Copenhagen Consensus is a well-known example.[2]).

Thomas Schelling defends the first view:

> "Any model that treats greenhouse gas abatement as a matter of investing now in order to reap future benefits, as in domestic environmental programs, is simply inappropriate. . . . *Greenhouse gas abatement is a foreign aid program*, not a saving-investment program of the familiar kind" (Schelling/RFF 1999, 100; emphasis added).

His analysis starts with a critique of the social rate of time preference approach [recall: **SRTP = $\rho + \theta g$**] as the proper social discount rate. Schelling challenges the inclusion of pure time preference [**ρ**] in climate change analysis for two reasons: (i) the traditional concept of time preference as "impatience" relates to *my* willingness to forego *my own* consumption <u>now</u> for *my* *own* consumption later, rather than the current or future consumption of others; and (ii) notions of impatience cannot credibly be applied to situations that occur generations into the future.

Next, he problematizes the second term, **θg,** because it does not explicitly address the equity issue—i.e., who will benefit from action now to mitigate climate change effects? First, Schelling argues that the primary beneficiaries of greenhouse gas abatement now will be the *descendents* of the people who live in the poorer nations now. Some reasons: (a) 80 percent of more of the world's population live in poorer nations; (b) the economies of poorer nations and more dependent upon agriculture and so are arguably more vulnerable to climate change; and (c) climate change effects will likely be more pronounced 50-100 years from now than in the next 50 years. Next, although Schelling agrees with many economists that it is reasonable to assume that the per capita growth rate of consumption **g** will continue to rise in the future [i.e., **g > 0**], this "does not mean that the beneficiaries of GHG abatement [i.e., descendents of today's poor] will have higher levels of consumption." (Schelling/RFF 1995, 100-101.)

For Schelling the key application of the *principle of diminishing marginal utility*—i.e., poor people benefit more from an extra unit of consumption than rich people—to the equity issue is that the rich (the developed nations) have a choice whether to focus their unspent consumption toward the current generation of poor or toward their descendents. Since the benefits of climate change action now won't be realized until decades later (he argues), the choice is really between spending now to mitigate change effects for the descendents of the poor vs. spending now to alleviate other urgent needs, such as alleviating poverty, hunger, and disease. (A global consensus on such priorities, with measurable goals and strategic plans, is articulated in the United Nations' eight Millennium Development Goals.) In sum, Schelling argues for directing funds away from costly climate change mitigation strategies toward alleviating human misery now. (In this regard, his conclusions are consistent with those of the 2004 Copenhagen Consensus.) In his view, both the framework of BCA as well as the tool of SRTP are inappropriate for LDF project analysis.

Robert Lind—editor of a highly-regarded volume in discounting LDF projects (Lind 1982)—also rejects BCA as a decision-making framework in analyzing climate change response options, but he nevertheless consider BCA to be a very useful analytic tool. A key reason for Lind's negative assessment of BCA as a decision-framework in this context centers on the intractability of the *intergenerational equity transfer problem.* A bedrock principle of BCA is that costs to future generations that result from a course of action now (including the cost of no action) should be, in principle, indemnified by establishing a trust fund from investments over time in order to compensate those worse off in the future. The question is whether or not there is a way to insure that those who benefit from "no action now" will compensate those bearing the costs in the long-distant future. (The reverse intergenerational transfer is equally problematic.) Since society lacks trustworthy mechanisms to keep such investment trusts tamper-proof, Lind concludes that, "[d]esigning and implementing such transfers is virtually impossible, and the potential for an intervening generation to break the chain of transfer makes such transfer schemes virtually impossible to implement" (Lind/RFF 1999, 174-175).

Lind also points out that we don't know whether future generations will be better off or worse than the current generation. (Although Lind is agnostic on this point, Schelling, Cline, and most economists in this review assume that **g > 0.**) Thus, if we support the principle of intergenerational equity (i.e., indifference with respect to consumption now or in each successive generation), then arguably the social discount rate should be <u>increased</u> if future generations are expected to be better off, and it should be <u>decreased</u> if we expect our descendents to be worse off. Other uncertainties surrounding LDF projects abound "from people's tastes to their incomes, to technology, and to the state of the planet" (ibid.)

However, is the principle of intergenerational equity even tenable? Kenneth Arrow employs a standard pure capital model to analyze the principle of "equal treatment" across generations, and surprisingly concludes that: " . . .the strong ethical requirement that all generations be treated alike, itself reasonable, contradicts a very strong intuition that it is not morally acceptable to demand excessively high savings rates of any one generation, or even of every generation" (Arrow/RFF 1999, 16). Otherwise said, the attempt to insure equity across generations within the transactional framework of standard economic theory would require a very sharp decline in current consumption and appears to be futile.

Given the wide range of uncertainties facing any LDF issues such as climate change and the conceptual limitations of BCA, Lind—like Manne--argues strongly for a *sequential* decision-making framework: go slow on committing large amounts of capital now to climate change abatement. This buys time to: (a) learn more about the dynamics of the issue; (b) see if technology can provide more cost-effective options; and (c) invest scarce public resources in other, more urgent, and cost-effective projects (ibid.). With respect to the third reason, BCA has an important role to play in characterizing and measuring the opportunity cost of various public investment options.

Like Lind, Nordhaus candidly acknowledges the substantial uncertainties concerning the effects of climate change—including the possibility of catastrophic changes. Both defend the use of analytic tools such as BCA without vesting them with decision-making power. An understanding of shared professional and political responsibilities is called for:

> In thinking through the appropriate treatment of future surprises, to the natural scientists falls the crucial task of sorting through the apocalyptic scenarios and obtaining rough judgments as to the likelihood of different geophysical outcomes so as to distinguish between the likely, plausible, possible, and virtually impossible. To the social scientists falls the issue of assessing the probabilities, determining the clause of different outcomes, and devising sensible strategies in the face of such massive uncertainties. To our leaders falls the burden of ultimately deciding how to balance future perils against present costs. For all, this is a fruitful use of our collective talents, full of intellectual challenges and practical payoffs. (Nordhaus 1993, 508).

III. CONCLUSION

It is clear from even this brief and selective review of papers about discounting large-scale, distant-future (LDF) projects that little evidence of consensus has emerged about the numerical value or the proper theoretical basis for a social discount rate and, more generally, the applicability of benefit-cost analysis (BCA) to such projects.

It would be premature, however, to offer a detailed critique of these experienced and insightful authors on the basis of reading these few papers and the other cited sources. Since the papers in the RFF collection were written more than a decade ago, a more fruitful use of this space may be to examine briefly the relevance of these earlier papers with respect to the latest findings regarding global climate change—specifically with respect to the possibility that global climate systems may be approaching a "tipping point." The question is: *Are global climate changes trending toward a point of "no return" in which climate feedback mechanisms are reinforcing, and therefore accelerating, destabilizing patterns such as (expressed very simply): warming → less ice and snow cover → more warming?*

Examining the credibility of claims that a "tipping point" is imminent or already has been reached is clearly beyond the scope of this paper. However, it is prudent to consider these possibilities in light of the latest scientific evidence. Working Group I of the Intergovernmental Panel on Climate Change (IPCC) released its report, "The Physical Science Basis," in February

2007 as the first of four reports comprising the IPCC's *Fourth Assessment Report*. This first report clearly implicates human activity as a major factor in climate change trends:

> Global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values . . . The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide and primarily due to agriculture. (IPCC, February 2007, p2).

The second report of the IPCC Fourth Assessment, written by more than 1,000 scientists from dozens of countries, will be released in April and will address the "Impacts, Adaptation, and Vulnerability" of climate change. According to recent press coverage based upon draft reports, the final report of this second Working Group will likely include the possibility of stark consequences affecting tens—or perhaps even hundreds—of millions of people within a matter of a few decades, due to lack of water in arid areas, rising sea levels, the spread of disease, and the prospect of mass starvation (Borenstein 2007).

Assume for a moment that these early indications of major findings of the second Working Group are in the final report and are subsequently confirmed via peer review in an open manner. Such findings would clearly call for a re-appraisal of the sequential, "go slow," approach favored by most authors in the 1999 RFF collection of papers and many others as well.

The logic of a sequential decision approach to climate change abatement with only minimal investments now to mitigate and adapt to climate change has been persuasive. (See arguments by Manne and Lind summarized earlier in this paper.) This logic has been buttressed by two key widespread assumptions that merit re-examination in light of current scientific findings: (a) a positive rate of growth of consumption in the long-term (i.e., $\mathbf{g > 0}$ in the formula for the social rate of time preference: SRTP = $\boldsymbol{\rho + \theta g}$); and (b) the assumption that climate change is unlikely to result in significant economic and social disruption for the next 2-3 generations. These assumptions would then be vulnerable to dispute and possible repudiation.

I close with three comments and related suggestions:

Clarity and transparency of assumptions. Nordhaus is quoted earlier in this paper as arguing for a "division of labor" among scientists and leaders for analysis and decision-making "to balance future perils against present costs." In a democracy, this requires an informed public. Lind candidly highlights the information gap. Writing about growth models—the "workhorse" of economic analysis of climate change—he writes: "The problem is not that the utilitarian framework is in some sense absolutely wrong. It is that it is neither well understood nor accepted by elected decision makers, and it implies that we should take actions that are totally inconsistent with the choices our society actually makes" (Lind/RFF 1999, 177).

As a newcomer to the intricacies of the economics of global climate with no formal training in the advanced calculus of welfare economics, my initial experience in reading the RFF collection of papers was somewhat like coming into a theatre and starting to watch the second act of a play. It took awhile to locate other resources from which to develop my own derivation of the two approaches to the social discount rate described in Section I. If we are serious about responding to Lind's lament, more must be done to give nonspecialists in the arcane field of discount theory a chance to fathom fundamental policy choices in, for example, the social discount rate and their implications for future generations. (True, the two forms collapse into one at equilibrium and are identical in theory along the optimal growth path, given a specific social welfare function. [See Lind, ibid.] But what if society is, in fact, not on such a path?)

The grants economy. First, the standard framework for the papers and reports that I reviewed, as well as other analyses of the economics of global climate change, is *utilitarian welfare economics*, aka neo-classical economic theory—i.e., the economics of exchange. Many people have critiqued this theory and its axioms of nonsatiability and rational behavior to maximize individual utility. (For example, George DeMartino in *Global Economy, Global Justice.*) In the climate change discussion, the limitations of this framework is evidenced in the intractability of the intergenerational transfer problem discussed earlier in papers by Lind and Arrow. Lind agrees with Schelling that climate change abatement is essentially a one-way "gift" from one generation to future generations. And Arrow showed that unacceptably high savings rates by the current generation would be required to insure intergenerational equity.

Kenneth Boulding argues that exchange economics is an insufficient basis for understanding economic systems. In *The Economy of Love and Fear*, he presents a model and analysis of the "grants economy"—one-way transfers of goods and services in the form of *gifts* (based on love, or altruism) or *tribute* (based on fear) (Boulding 1973, Introduction). Simply stated, economics is the analysis of two-way transfers and one-way transfers of goods and services. Possibly some of the limitations and problems discussed above with respect to climate change could be illuminated by incorporating Boulding's model of the grants economy into the standard framework of analysis.

<u>Growth vs. development</u>. Given the sobering analysis so far from the Fourth Assessment Report, I contend that the implicit and explicit assumptions about "growth" in existing models and formulas used in analyzing the economics of climate change need to be re-examined with some urgency. For example, growth *per se* is a key variable in the formula for the social rate of time preference: $\mathbf{SRTP = \rho + \theta g}$. Here, the variable $\mathbf{g}$ denotes the average growth rate of consumption. Clearly, then, higher average growth rates of consumption imply higher levels of SRTP; they vary directly. Roughly speaking, this means more growth (as consumption) now means less value placed on future generations (in terms of consumption) and therefore greater

intergenerational inequality. In short, higher rates of growth in consumption now imply a devaluing of the material well-being of future generations.

This is what a number of economists have been saying for years, such as Herman Daly. In "Economics for a Full World," Daly distinguishes between *growth* (as quantitative increase) vs. *development* (as qualitative improvement) (Daly 2005, 103). He argues that a sustainable economy can support development but not growth without limit—and that the planet has reached its sustainable limit, or nearly so, as the title of his article indicates. As an ecological economist, Daly argues for *strong sustainability*, which views natural capital vs. other forms of capital primarily as complements instead of substitutes. (In contrast, Robert Solow favors a position of *weak sustainability* that is more flexible with regard to substituting human and financial capital for natural capital (Solow 1993, 181-182).

I close with two suggestions for replacing the measure of growth with GDP, as its deficiencies as a measure of well-being are well-known. First, examine the possibly of modifying the formula for the social rate of time preference as, say, $\mathbf{SRTP = \rho + \theta*\eta*\sigma*g}$, where η and σ represent, respectively, the rate of decline of natural capital and the rate of change in some combination of human/social/cultural capital. Alternatively, replace GDP with a measure that explicitly incorporates noneconomic capital , such as the Index of Sustainable Economic Welfare (ISEW), which is described, for example in a lengthy Appendix in *For the Common Good* (Daly and Cobb 1994).. Such approaches might contribute to greater transparency and informed public participation as the United States and other nations decide how to respond to the challenge of global climate change.

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End Notes

1. For the basics on the standard methods in benefit-cost analysis and discounting, see Field and Field, Chapter 6.

2. The Copenhagen Consensus project sought to prioritize among proposals for addressing 10 global challenges facing developing countries: civil conflicts; climate change; communicable diseases; education; financial stability; governance; hunger and malnutrition; migration; trade reform; and water and sanitation. In 2004 a panel of eight distinguished economists (including three Nobel prize winners) rated 17 proposals for action to address these 10 challenges (*The Economist*, June 3, 2004). The three strategies for addressing climate change ranked at the bottom: an 'optimal' carbon tax (15^{th}), the Kyoto Protocol (16^{th}), and a 'value-at-risk' carbon tax (17^{th}). Control of HIV/AIDS was ranked first. (In the analysis, each proposed action was assumed to have a $50 billion budget, so proposals were ranked according to estimated benefits.)

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