

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Collection/Record Group: Clinton Presidential Records
Subgroup/Office of Origin: Council of Economic Advisers
Series/Staff Member: Joseph Stiglitz
Subseries:

OA/ID Number: 9569
FolderID:

Folder Title:
IPCC [Intergovernmental Panel on Climate Change] - Volume III [1]

Stack:	Row:	Section:	Shelf:	Position:
S	20	5	9	3



cc: RS
S/K

11 Dupont Circle, NW, 6th Fl., Washington, DC 20036
(202) 328-9000 Fax (202) 328-5432

FACSIMILE TRANSMISSION COVER SHEET

PLEASE DELIVER TO:

NAME: Joseph Stiglitz

COMPANY: Council of Economic Advisors

FACSIMILE NUMBER: 395-6958

TELEPHONE NUMBER:

TRANSMISSION SENT BY:

NAME: William Cline

DATE: 5 / 30 / 95 **TIME:** 4:30pm

We are sending a total of 5 page(s) including this cover sheet.

If you do not receive all of the pages, please contact us as soon as possible at (202) 328-9000. Thank you.

Our facsimile number is (202) 328-5432

Follows proposed draft chapter changes to IPCC WGIII Discounting Chapter.

Proposed Draft Chapter Changes
IPCC WGIII Discounting Chapter
WR Cline
29 May 1995

p.1 line 41-42

the last clause of this sentence is a nonsequitor. The converse is precisely the case where the money is not being spent on emissions control. Revision:

~~provided that the money is spent on emission control~~ provided that the money is spent on investment (rather than consumption).

p. 4 line 5 insert for clarification:

.. a social welfare function (SWF) ...

p. 5 line 22:

The revision of the chapter to give greater weight to the descriptionist position runs the risk of confusing the readers about where the authors stand. I propose the following change:

"Those who hold the prescriptive view, including the authors of this chapter, emphasize:

p.5 line 28-31

This formulation is wrong. The central point is that efficiency is not well-defined unless valuation is present, and valuation requires a social welfare function. In any event, as formulated the statement invites the critique that since the future will be richer, there is no equity justification for emissions controls today. Ironically the case for control is really one of efficiency, not equity: it is inefficient to enjoy extra consumption today at the expense of a future loss of consumption greater than that warranted by the social discount rate.

One option is to cut this paragraph entirely. Otherwise, it should at least be amended as follows:

"distribution. They acknowledge that using a low discount rate may mean some a sacrifice in efficiency if the true opportunity cost of emissions reduction is a reduction in alternative higher-return investment rather than in current consumption; but they ...

p. 7 line 26 chop the reference to Cline at this point (it implies the Cline value is 0.5%; it isn't)

p. 8 line 19 Add footnote:

"SRTF becomes 1.5%." ^{FN} After taking account ...

FN. This is the rate proposed by Cline (1992), based on $\rho = 0$, $\theta = 1.5$, and $g = 1\%$ average percapita growth over a 300 year period.

p. 8 Line 32: KEY ADDITION:

Add paragraph:

A central premise in the prescriptive approach to discounting for global warming is that governments cannot plausibly enter into a firm commitment to undertake additional alternative investments designed explicitly to compensate future generations for greenhouse damage, in part because any such commitment could easily break down over the required time scale of two to three centuries. It is this fundamental "commitment problem" that drives the need for discounting consumption-equivalents at the S RTP rather than discounting at the investment rate of return. The same reasoning underlies the use of economy-wide consumption and investment shares for resources devoted to emissions controls, when applying the shadow price of capital to investment effects to obtain consumption equivalents. This approach assumes that the bulk of these resources will thus come out of consumption rather than investment.

p. 10

Lines 1-5: Change from "~~Some have claimed that on ethical grounds, it is difficult to support a rate of pure time preference much above zero.~~" to:

"There is a considerable tradition in the economics literature suggesting that on ethical grounds, it is difficult to support a rate of pure time preference much above zero because of a resulting discrimination against future generations (Ramsey, 1928; Mishan, 1975)."

line 19-20: Add a footnote:
"the assumption that $\rho = 0$."FN

FN. Technically, indifference to cross-country inequality at a given point in time implies instead that the other key parameter, the elasticity of marginal utility (θ), is zero. For a discussion of the tension between the lack of income redistribution across countries on the one hand and social evaluation of redistribution across generations on the other, see appendix 3B.

p. 10 lines 38-40:

I am skeptical about 16 percent average return on World Bank projects. The Bank has in fact been unhappy with the average return, and has shifted toward greater emphasis on project quality (World Bank Annual Report, 1994, p. 73). What is the source? Unless specifically verified, this should be chopped. Replace

~~A review of World Bank projects estimated a real rate of return of 16%; one study found returns of 26% for primary education in developing countries.~~

with

World Bank projects can often achieve real returns of 10 percent or more. Even in the OECD ...

p. 11 line 27

KEY ADDITION:

Add the following paragraph:

A central premise in the descriptive approach is that governments can commit over a timescale of two to three centuries to the earmarking of additional investments for the purpose of eventually compensating future generations for damage from global warming. This commitment assumption is perhaps the most fundamental difference between the prescriptive and descriptive approaches. Implicitly, the descriptive approach correspondingly assumes that rates of return to investment will not decline from their current levels despite the time scale of centuries; and that there is no "intertemporal transfer problem" of being able to assure that the goods and services generated by the today's damage-compensating investments will be of relevance to the distant future generations (Cline, 1992).

p.11 Line 37 Change:

~~In practice,~~ In principle, though not yet in practice in the cost-benefit and optimization analyses of global warming policy conducted to date (chapter __, "Integrated Assessment,"), the two alternative approaches appropriately refined could lead to similar results ...

p. 14 Line 8

after Rawlsian max-min principle
insert (appendix 3B);

p. 14 line 13

"other hand, if ρ ρ were positive ...

p. 15 line 20

Change to: "The general approach strategy taken throughout this chapter by the prescriptive approach (main text) is to calculate ...

p. 15 line 29

... discounting total consumption impacts as at the SRTTP, ...

p. 17 line 14

| approach noted ~~above~~ below

p. 28 line 16

add footnote:

"equivalent per unit of capital (Lyon 1995).^{FN}

FN. However, the higher end of this range derives mainly from incorporating assumptions about reinvestment behavior in the sector from which capital is drawn, a method that can lead to highly unstable shadow prices (Cline, 1992).

p. 29 line 33

| ... The result will be equivalent to

p. 34 line 31-32. Something wrong. States that $U'' < 0$ is inconsistent with the data. But for the most common utility function, logarithmic, $U'(c) = 1/c$ and $U''(c) = -1/c^2$. Convex means humped upward, in this context, which means that the marginal utility is declining, which means that the second derivative must be negative. Clarify or else drop lines 31-32.



INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

145 King Street West, Suite 1002, Toronto, Ontario M5H 3K6 CANADA
Tel: (416) 369-0900 Fax: (416) 369-0922

cc: RS
SK

MEMORANDUM

TO: Chapter 4 Lead Authors
FROM: James Bruce
RE: Deadline for Receipt of Revised Chapter
DATE: May 18, 1995

All chapters must be received by the Technical Support Unit by May 25. This leaves only two days for making 200 copies of the whole report. These copies must be sent by courier on May 29 to meet the IPCC rules for distribution in advance of the Working Group III Plenary.

Your cooperation in getting the revised chapter to the Technical Support Unit by May 25 will be greatly appreciated. Thanks!

Memo, 744

Post-It™ Fax Note 7671E		Date	# of Pages 1
To DR. JOSEPH	From JIM BRUCE		
Co./Dept. STIGLITZ	Co.		
Phone #	Phone #		
Fax #	Fax #		

May 1, 1995

MEMORANDUM FOR JIM BRUCE, CHAIRMAN IPCC WG3

FROM: Joseph E. Stiglitz

SUBJECT: Comments on Synthesis Report: Draft Outline (7 April) and Draft Report (20 April)

I am sorry I cannot join you in Athens; pressing business keeps me away. Thank you nonetheless for the opportunity to comment on the drafts.

The draft text and outline are a good start, especially on the physical science side. They do not yet contain many of the important insights from economics or decision sciences, which is where I will focus my suggestions.

I suggest a section that would go between "2. What is projected to happen...?" and "3. What options are available...?" in the 7 April outline. The new section would explain how to think about climate change from the point of view of a decision maker. This approach would allow many of the important economic insights to enter the discussion. Let me lay out a view of this section, showing how it connects to the sections before and after it in the current draft, and how it allows a coherent discussion of many of the major economic insights from the Working Group III report.

To explain the general idea of decision making under uncertainty, it may be helpful to refer to Pascal's wager. In discussing the existence or nonexistence of God, Pascal proposed -- to put his argument in the language of modern decision analysis -- two possible states of the world (either there is a God or there is not), and two possible actions (I can act as if there is a God, said Pascal, or as if there is no God). If there is a God, and I act as if there is, or if there is no God, and I act as if there is not, he said, there is no problem. If there is no God and I act as if there is, I will have wasted a certain amount of time and energy. But if there is a God and I act as if there is not, then I will suffer terrible consequences -- at least according to the theology of the 17th century.

Suppose that the (simplified) choice facing the world today is to take aggressive and costly action, to take moderate (and moderately costly) action, or to take no action. For simplicity, suppose we can make this decision only once, and thereafter are bound by the consequences of our choice. And suppose that in 50 years, the current uncertainties in climate change science will have been resolved, and we will know either that climate change is a big problem, or that it is not a big problem. What should we decide, given the information available today? That will depend on the costs of being wrong in either direction, and the probabilities that the uncertainty will be resolved either up (no problem) or down (big problem). Figure 1 shows the simple decision tree for this

problem.

The decision problem we actually face is of course far more complex. First, rather than one decision to be made now, there will be many decisions to be made over many years. Second, the uncertainties will not be resolved all at once, but rather one by one over many decades. Figure 2 shows a more realistic decision tree. An initial decision is to be made in 1995. One important uncertainty is resolved in 2010 (e.g., the cost of climate change mitigation programs). Learning from this new information, another decision is made in 2020, with the final uncertainty (e.g., the cost of climate change damages) resolved in 2045. The decision we actually face requires a decision process that is sequential (like this example), can respond to new information with mid-course corrections, and can include insurance, hedging, and the option value of alternative courses of action.

The actual problem facing governments is complicated by several other factors: the long time lags between emissions and effects, the potential for irreversible damages or costs, wide regional variations, multiple greenhouse gases of concern, and the global nature of the problem, which means that international trade considerations are crucial, and that emissions limitations in one country may be largely or fully offset by actions in other countries. Yet another complication is that the atmosphere is a public good, and moreover an international public good, in that all countries benefit from each country's reductions in greenhouse gas emissions.

Even in the presence of these complicating factors, several general conclusions apply. First, a well-chosen portfolio of policies will yield greater benefits for a given expenditure than any one option undertaken by itself; striking the appropriate balance requires taking into account costs, benefits, and risks. Second, efficiency requires that emission reductions occur where their cost is lowest, irrespective of who bears the financial responsibility.

Given the state of knowledge about climate change, what decisions are consistent with our preferences and resources? Irrespective of the consequences of climate change, policies that mitigate against or assist adaptation to climate change and have zero or negative net costs ("no regrets" policies) are clearly justified. If the evidence suggests that damages can be expected from climate change, then the expectation of damages provides a rationale for going beyond "no regrets" policies to those that incur positive net costs. The principles of risk aversion and portfolio balancing provide a rationale for further steps.

Comments on other portions of Draft Outline (7 Apr 95)

2 b) This section should mention differences in regional impacts, including the benefits of climate change likely to accrue to some regions.

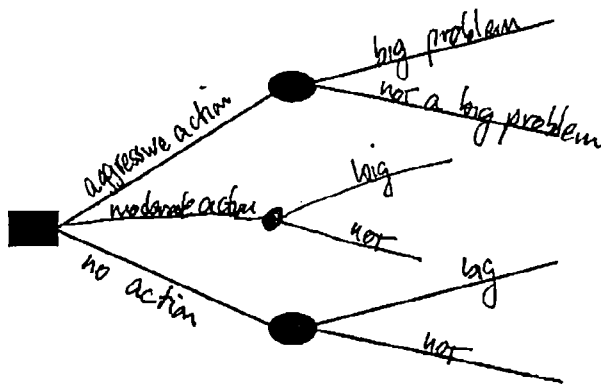
3 This section should say that through adaptation, markets will offset at least some of the

impacts expected from climate change.

4 b) Technological feasibility is perhaps less important than the economic costs of alternatives and the timing of emissions reductions. As the 14 Apr draft of the WG3 Summary for Policymakers puts it, "The overall costs of mitigation can be reduced by appropriately timing the reduction of emissions. Minimizing accelerated replacement of existing physical capital reduces the cost of achieving a cumulative CO2 emissions objective."

Also, this section should state that, in principle at least, questions of efficiency (what to do) and equity (who bears the burden) can largely be separated.

Simple Decision



Decision

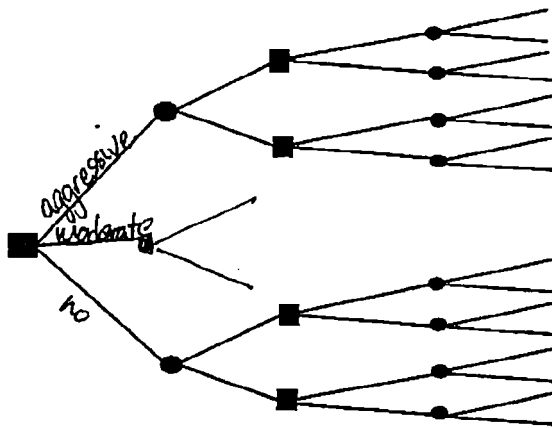
Uncertainty

Resolved

19985

2005 2045

Sequential Decisions



Decision 1

Uncertainty

1998/5

2005
2010

Decision

Uncertainty

2

2

2010
2020

2020
2045

**FACSIMILE COVER SHEET
OFFICE OF ECONOMIC POLICY**

DATE: 2 MAY 95

NUMBER OF PAGES TO FOLLOW: 4

FAX TO: JOE STIGLITZ & SALLY KANE
CEA

ADDRESSEE'S FAX NUMBER (202) 395-6058

ADDRESSEE'S CONFIRMATION NUMBER _____

FAX FROM: RAY SQUITIERI
TREASURY

SENDER'S FAX NUMBERS: (202) 622-1294

SENDER'S CONFIRMATION NUMBER: (202) 622-2350

COMMENTS/SPECIAL INSTRUCTIONS:



EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL OF ECONOMIC ADVISERS
WASHINGTON, D.C. 20500

MEMBER

May 2, 1995

MEMORANDUM TO BOB WATSON

FROM: Joseph E. Stiglitz

SUBJECT: Further Comments on "4.0 Decision Making Framework" faxed 5/2

PAGE 1

1. The second paragraph should highlight cost-benefit analysis and decision-theoretic frameworks to describe tools of used by economists. Replace the paragraph beginning with "Three analytic approaches ... " with:

"Economists focus on the use of cost-benefit analysis and decision-theoretic frameworks for deciding on the level at which greenhouse (as concentrations should be stabilized)."

2. The fifth paragraph describes the importance of "rate of change constraints" in meeting the objectives of Article 2 of the FCCC. If cost-benefit analyses are designed properly, they would already include such concerns.
3. The definition of safe minimum standard in the sixth paragraph seems flawed. As it is written, the approach is included in cost-benefit analysis.
4. I do not understand paragraph 7.

PAGE 2

1. Paragraph 2 needs to be set in the appropriate context. Following changes should be made:

Add this sentence to begin the paragraph: "Some non-economists advocate an alternative approach".

Rewrite the second sentence to read: "Environmental standards designed to protect human health **have been established in some countries** using this approach, **though these standards have increasingly come under attack**."

2. The end of paragraph 3. The challenge is to design the best long-term policy, with built-in flexibility. The wording of the paragraph following the first sentence is awkward and possibly misleading, but I believe the concepts are correct.

May 2, 1995

MEMORANDUM TO BOB WATSON

FROM: Joseph E. Stiglitz

SUBJECT: Comments on "4.0 Decision Making Framework" faxed 5/2

The text contains some good points, particularly the statement in the last paragraph that near-term emissions levels are not sensitive to ultimate stabilization level above 450 ppm.

It does not, however, provide the reader with the decision making framework promised in the title. Rather, it includes observations on a variety of topics of varying degrees of importance, loosely strung together, without an underlying structure. To leave it this way would be a serious mistake.

I suggest that the section set out a framework for how to think about these issues from the point of view of the decision maker. As I indicated in my memo of yesterday evening, this simplifies the structure of the problem, and provides the reader with a manageable set of issues. It explains the unique analytical complexities of climate change, and provides a logical setting for the major conclusions that economic has provided to date.

Specific comments

"The outcome of a collective decision making process often differs from the analytically determined global optimum." This seems to open the door to irrational policies. It may be true that governments do many things that scientists would not find justified, but we should be careful not to provide scientific cover for irrational decisions, merely because they are "collective." Also, this comment, the first sentence of the section, is nowhere followed up.

"Affordable safe minimum" and "absolute standard" approaches will not make sense to economists. I suggest the section not be made to stand or fall on the basis of these approaches, as it might invite rejection of the entire package.



MEMBER

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL OF ECONOMIC ADVISERS
WASHINGTON, D.C. 20500

bcc: Robert Watson

May 2, 1995

MEMORANDUM FOR JIM BRUCE

FROM: Joseph E. Stiglitz

SUBJECT: Summary for Policy Makers

cc: Erik Haites

I have read the latest version of the summary for policy makers for WG3, dated April 14th. I am passing along the most important concerns. Next week, when I am back from my trip to the OECD, I will be able to finish more detailed remarks and give specific examples to document the following three points.

1. I think it is imperative that the policymakers summary not emphasize views that deviate from the "main stream" without at least appropriately noting that these are not mainstream economists' views. It *may* be appropriate to refer to non mainstream views, but in doing so, it should be noted that these are views that are not widely shared. Not doing this will greatly hurt the credibility of the report.
2. While it is important to make the policymakers summary accessible to non-economists, one must be careful about using vocabulary which will annoy economists.
3. Finally, one must be extremely careful about normative statements, except when there is a clearly stated axiomatic basis. Assertions about values, though they are obviously important in making decisions, do not represent part of the scientific contribution that WGIII can make.

Fax 001-202-456-0025

LET TO J. STICLITZ

FOR COMMENTS AS SOON AS POSSIBLE

Bob Watson #554

4.0 Decision Making Framework

The Framework Convention on Climate Change establishes a collective decision making process. The outcome of a collective decision making process often differs from the analytically determined global optimum.

Economists focus on the use of cost-benefit analysis and decision-theoretic frameworks for deciding
~~Three analytical approaches can be used to decide on the level at which greenhouse gas concentrations should be stabilized:~~

~~cost-benefit analysis;~~
~~affordable safe minimum standard approach; and~~
~~absolute standard approach.~~

A benefit-cost analysis seeks the atmospheric concentration that minimizes the total cost of climate change damage, mitigation cost, and adaptation cost to society. Economists prefer a benefit-cost framework for decision making since this approach seeks the outcome that uses society's resources most efficiently. Application of benefit-cost analysis to climate change is complicated by: the uncertainties inherent in valuing damages, assumptions about the costs of future energy technologies, the long time horizons involved, and the critical role of the discount rate.

In general, a benefit-cost analysis would NOT suggest that atmospheric concentrations of greenhouse gases rise/fall to a particular level and then remain at stable at that level indefinitely. Rather better information on impacts of climate change, changes in damage values due to changes in incomes, changes in the costs of energy technologies and other developments would lead to changing optimal concentrations over time.

It may be necessary to incorporate rate of change constraints into the benefit-cost analysis to meet fully the objectives of Article 2. For example, constraints might be needed to allow enough time for ecosystems to adjust naturally, to ensure that food production is not threatened, or to enable economic development to proceed in a sustainable manner.

An affordable safe minimum standard specifies maximum atmospheric concentrations of greenhouse gases or rate of change based on an assessment of the risks associated with and the costs of achieving each standard. For a proposed standard, the total cost is the sum of the climate damages incurred, the adaptation costs incurred to minimize those damages, and the cost of the least cost set of mitigation measures to achieve the stabilization level. Conceptually it is possible to compare the total cost of a series of possible standards. Such cost estimates are not yet available in the literature because the integrated assessment models needed to make such estimates are still at a relatively early stage of development.

I don't understand this
 For many potential standards, the total cost to society will be higher than that for the pattern of atmospheric concentrations determined through benefit-cost analysis. The higher cost represents an inefficient use of society's resources. For

part of cost-benefit analysis

flawed description of S.M.S. - if this is all it is, should just use cba

stabilization targets that exceed the highest concentration of the benefit-cost pattern the cost of inefficiency falls to zero since there would be no reason to exceed the socially-optimal pattern. In principle, then, the loss of efficiency due to adoption of a safe minimum standard can be made as small as decision makers wish.

muddled

As the concentration and/or rate of change standard rises, the mitigation costs tend to fall while damages and adaptation costs rise. Beyond some concentration the mitigation cost savings become quite small while damage and adaptation costs continue to rise. Achieving a given standard more quickly tends to raise the total cost.

*? don't understand
/V ok*

Some non-economic advocate an alternative approach.

An absolute standard approach bases the concentration and/or rate of change standard on predicted bio-physical impacts regardless of cost. Environmental standards designed to protect human health are often established using this approach. An absolute standard approach, however, is not consistent with Article?? of the Convention which states that the objectives should be achieved cost-effectively. (to be checked)

*for some countries**have been
- though these
have
increasingly
come
under attack.*

One way to cope with the uncertainties that affect estimation of benefits and costs is to adjust the decisions continuously as new information becomes available. The available studies suggest that the economically optimal actions to limit CO₂ emissions over the next few decades are very similar for all concentration levels in excess of 450 ppm. The challenge, then, is not to find the best policy now for the next century, but to select a prudent strategy and to adjust it in the light of new information. Since climate change strategies are likely to change, there is a risk that some measures will subsequently be uneconomic. However, inaction also entails risks. Both of these risks should be incorporated into the assessment of potential climate change actions.

*Risky
working
but
ok*

Chapter 3

Intertemporal Equity, Discounting, and Economic Efficiency

Lead Authors:

Kenneth J. Arrow, William R. Cline, Karl-Goran Maler,

Mohan Munasinghe, and Joseph E. Stiglitz

April, 1995

3.1 Introduction

This chapter focuses on methods for comparing costs and benefits that fall at different times, especially where trade-offs occur across generations. How we think of these trade-offs involves issues of intertemporal equity. This issue is a matter of philosophy (and for some, religion and morals) because it involves reaching judgements about what is fair or just. The issue is also a matter of economics, because comparisons across time are appropriately judged in the light of changing standards of living over time as well as opportunities for productive investment.

3.1.1 Importance of the Discount Rate

The discount rate is the analytical tool that allows economists to compare economic effects occurring at different points in time. Identifying the appropriate discount rate has been discussed in the context of general cost-benefit analysis (chapter 5) for many years (Dasgupta et al. 1972, Harberger 1976, Little and Mirrlees 1974, Sen 1967, Stiglitz 1982). Social scientists have debated the precise rate to use for global climate analysis (Broome, 1992; Cline, 1992; Nordhaus, 1993); analysts agree that the choice of a discount rate powerfully affects the analytical results.

Investments in both physical capital (e.g. machines) and human capital (e.g. education) yield on average a positive real return. That is, money invested today can be transformed into more money later, even after adjusting for inflation. Discounting converts each future dollar amount associated with the project into the equivalent present dollar amount that must be invested today in the general economy in order to yield the same future amount. Greenhouse gas emission control may be viewed as an investment: money is spent today on emission controls today so that more money (or other benefits) may be received later in the form of reduced economic costs of global warming. If the real rate of return on investment in emission reduction exceeds the rate on investment in machines and education, then future generations would be better off if less were invested today in machines and education and more in controlling greenhouse gas emissions; the converse also holds.

Because the benefits of greenhouse abatement accrue decades or even centuries into the future, use of a high discount rate results in a low present value for actions that slow climate change. For example, at a discount rate of 8 percent annually (as is commonly used in short-horizon project analysis), damages of \$1 billion 50 years hence have a present value of only $[\$1 \times 10^9] / [1.08^{50}] = \21.3 million; the same damages 200 years hence have a present value of only \$200.

The question of the appropriate discount rate involves issues in normative as well as positive economics. How (ethically) should impacts on future generations be valued? To what extent will investments made to reduce greenhouse gas emissions displace investments elsewhere? The debate is often confusing, because three separate issues are being addressed: how to discount the welfare or utility of future generations; how to discount future dollars; and how to discount future pollution. Further, the argument often combines questions of efficiency with questions of ethics, and economists have no special claim to professional expertise in questions of ethics.

Climate policy raises particular questions of equity among generations, because future generations are not able to influence directly the policies being chosen today that will affect their well-being (Mishan, 1975; Broome, 1992), and because it might not be possible to compensate future generations for reductions in well-being caused by current policies.

3.1.2 Areas of Agreement and Disagreement

3.1.2 Is Discounting Relevant?***THIS BOX WILL BE MODIFIED***

One prominent economist, Thomas Schelling, has rejected the use of discounting for climate change projects, arguing that it requires the assumption of utility maximization by a single representative individual who lives forever. Schelling emphasizes that the essence of climate change is that those likely to bear the cost of mitigation—the developed countries—differ from those likely to enjoy the benefits—the currently developing countries. Thus he emphasizes the importance of distributional considerations.

Supporters of the approach set out in this chapter note that the model of one immortal individual is used only for exposition, and that the results derived from the social welfare function approach presented here remain true even with many individuals (or countries) within each generation.

Economists are in general agreement that the proper social rate of discount on goods is

$\rho + \theta g$, where ρ is the rate of "pure" time preference (the utility discount rate), θ is the absolute value of the elasticity of marginal utility, and g is the growth rate of per capita consumption. In evaluating competing projects, all spending, including investment, is to be converted into consumption equivalents first, then discounted at the social discount rate (Arrow and Kurz 1970, Lind 1982).

Economists are also in good agreement on the range of empirical estimates of returns to investment, and the average interest rate earned or paid by consumers.

In addition, economists generally reject environmentally specific egalitarianism, believing that future generations can be compensated for some environmental/natural resource effects by offsetting accumulations of capital. On the other hand, they accept more generalized (but not, usually, absolute) egalitarianism, believing that differences in the overall standard of living should be reflected in the discount rate. Thus if future generations are expected to be wealthier than the current one, extra units of consumption will be valued less.

Economists disagree on several other issues--the degree of economic efficiency, the existence of market imperfections and constraints on policy, plus distributional concerns. These differences drive the differences in conclusions about the discount rate.

The next section sets out the building blocks of the analytical approach, introducing the key technical terms. There follows a presentation of the two most prominent approaches to discounting for climate change programs, together with the reasons for the differences in the conclusions they reach.

3.2 Building Blocks of the Analytical Approach

Economists begin with a social welfare function, an algebraic formulation relating that "adds up" the consumption of different individuals, yielding a number that measures well-being for the whole society. The scientific literature begins with analysis of conditions in the "first best" world: with complete markets and optimal tax policy it can be shown that

Pareto efficiency, competitive equilibrium, and social welfare functions

An economic allocation is **pareto efficient** if there is no way to make one person better off without making someone else worse off. A **competitive equilibrium** is pareto efficient as long as there are complete markets for all goods at all dates. But Pareto efficiency says nothing about distribution; an allocation that gives everything to one person is generally Pareto efficient. Moreover, many different Pareto efficient outcomes (or Pareto optima) exist.

A **social welfare function (SWF)** combines utilities of different consumers, and in effect selects one pareto optimum. For example, the utilitarian SWF is just the sum of different utilities, $W = \sum u_i$, where the u_i are utilities of different individuals. An alternative is the weighted-sum-of-utilities SWF, $W = \sum \alpha_i u_i$, where the α_i are the weights assigned to each person's utility. A third example is the Rawlsian or minimax SWF, $W = \min \{u_1, \dots, u_n\}$, which takes society's welfare as the welfare of the worst-off person. The SWF is the standard analytical approach to issues of equity.

the discount rate will equal the marginal product of capital, which will equal the interest rate faced by both producers and consumers (Lind 1982).

In this case, an optimal path must be efficient in three senses (Lind 1982):

1) production: the marginal rate of transformation in production between one period and the next, and thus the marginal product of capital, equals the producer rate of interest for all goods: $MRT_j(t, t+1) = r$, i.e. the marginal rate of transformation for any good j from period t to period $t+1$ equals the producer rate of interest r .

2) consumption: the ratio the marginal utility of consumption in period t to the marginal utility of consumption in period $t+1$ equals 1 plus the consumer interest rate, or $MUC_k(t)/MUC_k(t+1) = 1 + i$; and

3) overall: the consumer interest rate equals the producer interest rate for all goods, for all consumers, in all time periods: $i = r$.

The literature then addresses departures from the "first-best" assumptions. If intergenerational transfers are possible, then the efficiency requirement continues to hold, and the discount rate must equal the marginal product of capital (Stiglitz 1982). Even with a non-optimal tax policy (i.e., with differing tax rates on different forms of income), but with no constraints on income transfers, efficiency is still required, but the discount rate may not equal the marginal product of capital (Stiglitz 1982). In this case, no single discount rate can be applied; rather, efficiency requires project-specific discount rates. With sub-optimal taxes, and constraints on intergenerational transfers, market rates are no longer a reliable indicator of the appropriate discount rate, which may be greater than or less than the before-tax return on investment (Stiglitz 1982). In this case, no general theoretical rule connects the discount rate to any observed market rate, although market rates still contain valuable information that should be used in arriving at a discount rate.

What is called below the **prescriptive approach** begins with a social welfare function constructed from ethical principles. It emphasizes departures from "first-best" conditions, especially non-optimality of the tax system, and constraints on intergenerational transfers. What will be called the **descriptive approach**, on the other hand, begins with the the SWF implied by actual government and private decisions (the prescriptive approach, in contrast, implicitly assumes this SWF is wrong, and attempts to improve on it). The descriptive approach says that decisions or public investments should be consistent with this SWF, and looks to actual behavior to determine a discount rate consistent with that SWF. While the descriptive approach assumes that governments are already undertaking transfers across generations that are optimal under the prevailing SWF, the prescriptive approach assumes that governments cannot or will not do so.

3.2 Prescriptive Approach

Those who hold the prescriptive view emphasize:

- 1) market imperfections, especially suboptimal tax policy;
- 2) constraints on policy, especially the difficulty in making transfers to future generations;
- 3) distribution. They acknowledge that using a low discount rate means some sacrifice in efficiency; but they point to the suboptimal structure of current tax policy, and believe that, as with other programs with a goal of distributional equity (such as food subsidies), the gain in equity justifies some loss in efficiency; and
- 4) equalizing the marginal utility of consumption. They assert that public investment should equalize the marginal utility of society's consumption at different times.

3.3.1 Formulation of Prescriptive Approach

The fundamental equation for the discount rate of consumption, or the "social rate of time preference" (SRTP) is, as stated above:

$$3.1) \text{ SRTP} = \rho + \theta g$$

The first term (ρ) is the rate at which utility is discounted because it occurs later rather than sooner. Sometimes this term, the rate of pure time preference, is referred to as discounting for impatience or myopia. The second term (θg) is the rate at which changes in consumption levels are discounted to be translated into the resulting changes in utility or welfare levels. The idea is that if per capita consumption is growing a rate g , then an extra unit of consumption in the future should be discounted by the term θg to take account of the lower marginal utility of consumption at higher consumption levels.

Even if future generations are given weight equal to that for current generations, so that pure time preference (ρ) is zero, there could still be an important basis for discounting future consumption: people are expected to be better off, so that an extra unit of consumption would not be worth as much in the future as today. ***** OTHER REASONS? ***** Thus, if technological change continues at its pace over the last century, with productivity and living standards doubling every thirty years or so, then marginal changes in consumption of those future generations should be weighed much less. This consideration is captured by the second right-hand term in equation 3.1.

The prescriptive approach arrives at the following conclusions:

1 1. For discounting total impacts on consumption (or welfare) across generations: The
2 social rate of time preference, which reflects society's views concerning trade-offs of
3 consumption across generations, should be employed. The proper discount rate, while
4 affected by observed market (producer) rates of interest through the effect of market
5 rates on the value of foregone investment alternatives, are not in general equal to these
6 market rates.

7
8 2. For discounting direct costs and benefits of a greenhouse mitigation project: The cost
9 of a greenhouse mitigation project must include the foregone benefits of other competing
10 investments not undertaken. If a mitigation project would displace private investment,
11 and returns to both projects accrue to the same generations, then it is appropriate to use
12 the opportunity cost of capital -- the private return -- in discounting. Only after doing
13 this will it be appropriate to use the social rate of time preference.

14
15 3. Evaluating risk: uncertainty about the impacts (changes in consumption) can be
16 incorporated by analyzing their *certainly equivalents* (the certain result that would make
17 an individual indifferent between it and the uncertain outcome), and discounting the
18 certainty equivalents in the manner described above.

19
20 4. Evaluating environmental impacts: environmental impacts can be incorporated in an
21 analogous way--converting them to consumption equivalents, and discounting at the rate
22 described above. Under plausible assumptions, the relative price of environmental goods
23 will increase over time, which would have consequences equivalent to adopting a lower
24 discount rate for such goods at unchanged prices.

25
26 Appendix 3B (Technical Notes) discusses these issues in more detail.

27 28 3.3.4 Discount Rate Estimates -- Prescriptive Approach

29
30 The prescriptive approach, beginning with a SWF derived from ethical principles, leads
31 to low discount rates for changes in consumption of future generations. With high rates
32 of productivity increase (and high g), of the order of 1.5%, and high values of the
33 elasticity of marginal utility (θ), the social discount rate is of the order of 3%; with low
34 rates of productivity increase, of the order of .5%, and low values of the elasticity of
35 marginal utility, the social discount rate is of the order of .5%.

36
37 It must be emphasized that these **discount rates apply to consumption only**, and that
38 they can be applied only after the foregone benefits of other investments have been
39 included in the costs of the program.

40
41 *****Move this sentence*****Those who advocate the prescriptive case sometimes claim that
42 without the ability to make intergenerational transfers, and without the right tax policy,

1 the SRTP will in general fall below the producer rate of interest.

2
3 In general, there is no reason why the discount rate should be constant over time even if
4 ρ and θ are constant, since g need not be constant. In fact, if we assume a gloomy
5 scenario where future output and consumption decline, then g and thus the SRTP may
6 be negative (Munasinghe, 1993).

7
8 Developing countries, with higher rates of productivity increase, can justify higher rates
9 of discount, at least until the gap between their standards of living and those of the more
10 developed countries has been closed. With labor productivity increases and per capita
11 income growth of the order experienced by the Asian miracle countries of 5 to 8% per
12 year, and elasticities of marginal utility of 2, discount rates of the order of 10% to 16%
13 could be justified. Similarly, low-income countries close to subsistence levels could have
14 high elasticities of marginal utility (rapid dropoff of marginal utility from initially
15 extremely high levels associated with privation), so that their SRTPs could be high even
16 if they were experiencing slow growth over long periods. These distinctions have
17 important implications for global warming policy, because they would tend to mean that
18 the calculus of trading off present abatement costs against future benefits from avoidance
19 of global warming damage could be less attractive for developing countries than for
20 industrial countries. However, there are other elements in the calculus that could go the
21 other way, such as the likelihood of higher relative future damage from global warming
22 for the developing countries (see chapter 6).

23
24 Specific applications in the still new economic literature on global warming have adopted
25 different discount rates. To follow the approach suggested by Cline (1992), with a zero
26 rate of pure time preference (ρ), and using the consumption growth rate of 1.6% per
27 capita from the IPCC scenarios (IPCC 1992) multiplied by an elasticity of marginal
28 utility (θ) of 1.5, gives an SRTP of 2.4%. If instead it is assumed that per capita growth
29 is only 1% (perhaps because of slower growth after 100 years), or if $\theta = 1$, then the
30 SRTP becomes 1.5%. After taking account of the share of resources coming out of
31 capital (20% economy-wide, versus 80% out of consumption) and taking into account the
32 opportunity cost of displaced capital and depreciation, the effective discount rate
33 becomes 2% to 3%.

34
35 Annex 3A gives details of the mathematics of the social rate of time preference. In
36 using the SRTP approach, we value the total change in consumption at each date, not
37 just the direct outputs of the project. *If the project displaces private investment* that has a
38 high marginal product, then there will be a large loss in output and future consumption
39 resulting from the displacement. The prescriptive view takes into account *opportunity*
40 *costs in calculating changes in consumption*, but in valuing the changes in consumption,
41 uses the SRTP. In short, all effects are converted to their consumption equivalents, then
42 discounted at the SRTP.

3.4 Descriptive Approach

The descriptive approach begins with the SWF inferred by the evidence from actual government and private decisions. Believing that no justification exists for choosing a SWF other than what decision makers actually use, advocates of the descriptive approach advise decision makers to choose the action that satisfies the intertemporal efficiency conditions, and thus leads to the greatest total consumption (Nordhaus 1994). In this approach, transfers to future generations, if necessary, are to be considered separately. Advocates of the descriptive approach often call for inferring the social discount rate from current rates of return and growth rates (Manne 1994).

3.4.1 Formulation of Descriptive Approach

The descriptive approach to the discount rate looks at returns to investments in the real world, and with this information seeks intertemporal efficiency. It asks: could consumption be increased at one date without decreasing it at any other?

The **descriptive** approach says that if a policy is not intertemporally efficient, it should not be adopted. An important difference between the two approaches is that the descriptive approach includes the opportunity cost of capital directly, while the prescriptive approach includes it indirectly, as the example of project evaluation illustrates (see box below). Most global warming optimization models (e.g. Nordhaus, 1993a, b; Peck and Teisberg, 1992; Manne et al., 1993) rely on the descriptive approach. In practice, both approaches may lead to similar results, and similar policy recommendations.

Combine and Fix next 2 paras

Some have claimed that on ethical grounds, it is difficult to support a rate of pure time preference much above zero. But on the same ethical grounds it is equally difficult to support development assistance budgets for the OECD countries that average as low as one quarter of one percent of GDP, to cite one example. Yet this is what occurs in the real world.

That opportunity costs (market rates of return) usually exceed the SRTP suggests the existence of better alternatives than those barely satisfying, say, a two percent rate of return criterion. At this point the question becomes: why has the SRTP not been brought into accord with observed market rates of return? In the context of climate change, the central argument of the prescriptionists is that other alternatives are not feasible. As suggested earlier, society is not likely to be able to set aside investments over the next three centuries and earmark the proceeds the eventual compensation of those adversely affected by global warming. Even if such a commitment could somehow be made, there would be no guarantee that the rate of return on capital would remain

where it is today over this period.

Accordingly, if the long-term consumption rate of discount is 1% to 2%, say the prescriptionists, then a climate change investment returning 2% is better than no

Example: Project Evaluation using prescriptive and descriptive approaches

Suppose a greenhouse mitigation project is under consideration. If undertaken now, it will cost \$1 million. If not undertaken, a new sea wall might be required in year 50, costing \$10 million. If it is necessary, building a sea wall would avoid damages of \$ 1 million per year.

capital cost:	\$ 1 million
time until damages begin	50 years
cost of sea wall, year 50	\$10 m
avoided damages, years 50,51,52,53,...	1 m/yr
opportunity cost of capital:	5 %

The decision maker has 4 options:

- Do nothing (year 0), do nothing (year 50)
- Do nothing (0), build sea wall if necessary (50) --
- Mitigation project (0), do nothing (50)
- Other investment (0), build sea wall if necessary (50)

The stream of benefits is as follows:

Option (year)	0	...	50	51	52	...
a.	0	...	0	0	0	
b.	0		-10	1.0	1.0	...
c.	-1		1.0	1.0	1.0	...
d.	-1		11.5	1.0	1.0	...
			-10			
			=1.5			

At most plausible discount rates, option b dominates option a -- i.e. if the sea level rises, it is better to build the sea wall than do nothing. Option d dominates option c, as investing the \$1 million in year 0 at 5% yields \$11.5 million in year 50, enough to build the sea wall with \$1.5 million left over. But option d may be institutionally infeasible, as there may be no way to put aside \$1 million today and leave it untouched for 50 years in a sort of Fund for Future Greenhouse Victims. If d is infeasible, then the choice between b and c will depend on the value attached to the extra consumption along path b in years 0 to 49; this will depend on the consumption rate of discount.

investment at all. To the argument that a discount rate of 2% is glaringly inconsistent with observed behavior (e.g., government spending on education or research, development assistance by donor countries), prescriptionists reply that just because the government fails to allocate resources properly in one area is no reason to insist that decisions in other areas be consistent with that initial decision.

3.4.1 Returns to Investment and Discount Rate Estimates -- Descriptive Approach

Nordhaus (1994), Lind (1994), Birdsall and Steer (1993), and Manne (1994), among others, have all stressed the importance of the opportunity cost of capital. A review of World Bank projects

estimated a real rate of return of 16 % at project completion; one study found returns of 26% for primary education in developing countries.

Even in the OECD countries, equities have yielded over 5% for many decades, after corporate and other taxes, comparable to a pretax rate of at least 7%.

Further, selecting a low discount rate of 2% implies far more investment than actually occurs in any country now, and thus would require a big jump in savings rates to finance the increased investment (Manne 1994).

Manne uses a standard growth model to

Estimated returns on financial assets and direct investment

Asset	Period	Real return (%)
High-income industrial countries:		
equities	1960-84	5.4 (a)
bonds	1960-84	1.6 (a)
nonresidential capital	1975-90	15.1 (b)
govt. short-term bonds	1960-90	0.3 (c)
U.S.		
equities	1925-92	6.5 (a)
all private capital, pretax	1963-85	5.7 (d)
corporate capital, posttax	1963-85	5.7 (e)
real estate	1960-84	5.5 (a)
farmland	1947-84	5.5 (a)
Treasury bills	1926-86	0.3 (c)
Developing countries:		
primary education	various	26 (f)
higher education	various	13 (f)

Sources: (a) Ibbotson and Brinson 1987, updated by Nordhaus 1994; (b) UNDP 1992, table 4., results for G-7 countries; (c) Cline 1992; (d) Stockfisch 1982, 1989; (e) Brainard, Shapiro, and Shoven 1991; (f) Psacharopoulos 1985.

1 examine the relation between discount rates and savings rates in the context of
2 developed economies. He finds that discount rates of one or two percent imply an
3 unrealistically rapid near-term increase in the rate of investment. Manne thus concludes
4 that a rate this low is grossly inconsistent with observed or plausibly anticipated behavior.
5 On the other hand, critics might interpret Manne's analysis as showing that the
6 intertemporal equilibrium established by market economies differs markedly from that
7 corresponding to the solution of an intertemporal maximization problem based on a
8 social welfare function derived from ethical considerations¹.

9
10 But even if savings could be increased enough to drive the discount rate to one or two
11 percent, climate change investments would still have to compete with many other public
12 and private investments offering higher returns. Birdsall and Steer of the World Bank
13 (1993) explain the problem:

14
15 ... we feel that meeting the needs of future generations will only be possible if
16 investable resources are channeled to projects and programs with the highest
17 environmental, social, and economic rates of return. This is much less likely to
18 happen if the discount rate is set significantly lower than the cost of capital.

19
20 These apparently small differences in rate of return result in large differences in long-run
21 results. An investment at even 5% returns 18 times more than one at 2% over 100
22 years. Thus, society would be foolish to forgo a 5% investment for a 2% investment.

23
24 The descriptive position in effect assumes no constraints on bequests to future
25 generations, and no tax distortions. As has been demonstrated (Stiglitz 1982), in the
26 presence of constraints on transferring income to the future, maximizing the SWF need
27 not imply productive efficiency, which means that the producer's rate of interest need not
28 be the social discount rate.

Annex 3A Methodological Notes on Discounting

3A.1 Intertemporal Maximization of Well-Being

In an influential series of articles, Koopmans (1960) conducted a series of thought-experiments on intertemporal choice so as to see the implications of alternative sets of ethical assumptions in plausible worlds. He suggested that we can have no direct intuition about the validity of discounting future well-beings, unless we know something concrete about feasible development paths. Applying this approach, Mirrlees (1967) and Chakravarty (1969) showed that in plausible economic models for developing countries, not to discount future well-being could imply that the present generation be asked to save and invest around 50 per cent of gross national product -- a stiff requirement when GNP is low. Nonetheless, these models tended to assume high rates of return on capital (a constant 33 percent rate in Chakravarty, 1969) and to consider time periods of decades rather than centuries. It is unclear that their findings hold for the centuries-scale problem of global warming, in part because of the much lower likely average return to capital over this time.

Koopmans (1960) considered the set of feasible consumption paths (from the present to the indefinite future) and the corresponding set of welfare or "well-being" paths. These paths could then be ordered to select the optimum path of well-being, according to the criterion:

$$3A.1) z = \int_{t=0}^{\infty} W(c_t) e^{-\rho t} dt$$

where $\rho > 0$.

Correspondingly, the discount rate for the time path of consumption is:

$$3A.2) i_t = i(c_t) = \rho + \theta(c_t) [dc_t/dt]/c_t$$

where $\theta(c_t)$ is the elasticity of marginal well-being, or marginal utility, at time t (Arrow and Kurz, 1970). (Note that whereas the main text treats this term as a constant, it is explicitly considered to vary with the level of consumption in the treatment here.) Along a full optimum path, the consumption rate of discount equals the productivity of capital (i.e. the social rate of return on investment). This is the famous Ramsey Rule (Ramsey 1928).

A convenient form of W is that giving a constant elasticity of marginal utility, such as:

$$3A.3) W(c) = c^{-\theta}$$

As discussed in the text, the larger is the rate of pure time preference (ρ) the lower is the weight accorded to future generations' well-being relative to that of the present generation. Mirrlees's (1967) computations essentially introduced this sort of bias ($\rho > 0$) as a way of countering the advantages to be enjoyed by future generations, should the productivity of capital and technological progress prove to be powerful engines of growth.

A higher value of θ means greater emphasis on intergenerational equity. As $\theta \rightarrow \infty$, the well-being functional in 3A.1) resembles more and more the Rawlsian max-min principle; in the limit, optimal growth is zero.

In 3A.3), $W(c)$ has no minimum value. If $\rho = 0$, this ensures that very low consumption rates are penalized by the optimality criterion reflected in (3A.1). On the other hand, if ρ were positive, low consumption rates by generations sufficiently far in the future would not be penalized by (3A.1). This means that unless the economy is sufficiently productive, optimal consumption will tend to zero in the very long run. Dasgupta and Heal (1974) and Solow (1974a) showed in a model economy with exhaustible resources that optimal consumption declines to zero in the very long run if $\rho > 0$ and in the absence of technical change, but that it increases to infinity if $\rho = 0$.

It is in such examples that notions of sustainable development can offer some analytical guidance. If by sustainable development we mean that the chosen consumption path should never fall short of some stipulated, positive level, then it follows that the value of ρ would need to be adjusted downward in a suitable manner to ensure that the optimal consumption path meet the requirement. This was the substance of Solow's remark (see Solow, 1974b) that, in the economies of exhaustible resources the choice of ρ can be a matter of considerable moment.

So far an assumption underlying this discussion has been that well-being or utility has not been bounded. If we restrict well-being to be bounded, other results obtain, because of the mathematical properties of the space of bounded sequences. For such sequences present value calculations are not rich enough to capture all of the subtleties of evaluation of a utility stream. Instead, one has to add to the present value another term. Chichilnisky (1994) has suggested that the present value term represents the requirement that the future should not be a dictator over the present; and that the second term represents the requirement that the present should not be a dictator over the future. This second term will in general have the form of a long-term average. It could be approximated by minimum requirements for the long run stocks of environmental resources. This formulation attempts to account for both basic levels of human needs and limitations on total resources.

Resource Sourcing and the Consumption versus Investment Discount Rate

Sandmo and Dreze (1971) address the choice of the correct rate of discount to use in the public sector when there are distortions in the economy, e.g. in the form of taxes, which prevent the equalization of marginal rates of substitution and transformation in the private sector. Under certain assumptions, the corporate tax drives a wedge between the marginal rate of time preference of consumers and the marginal rate of transformation in private firms.

They find that for a closed economy:

$$3A.4) 1+r < 1+i < 1 + r/(1-t)$$

where r is the consumer interest rate, t is the tax rate, and i is the public sector's discount rate. This rate should thus be a weighted average of the rate facing consumers and the tax-distorted rate used by firms. Since $1+r$ measures the marginal opportunity cost of transferring a unit of resources from private consumption, and since $1 + r/(1-t)$ is the measure for transfers from private investment, a unit of resources transferred from the private to the public sector should be valued according to how much of it comes out of consumption and how much out of investment².

The general approach taken throughout this chapter is to calculate impacts on consumption, and to find the appropriate discount factor for discounting those changes. We are, in effect, taking consumption as our *numeraire*. This is convenient and natural, but there are other ways of performing the calculations, using other numeraires. Using other numeraires, relative prices over time (discount factors) will differ from those associated with the consumption numeraire. The failure to recognize this is a great source of confusion in the discounting literature. Thus, as suggested in section 3.7, if environmental goods had been chosen as the numeraire, the discount rate could even have been negative. It is important to remember, however, that nothing substantive depends on the choice of numeraire.

By the same token, if for example systematic relationships exist between the outputs and inputs of a project and the total changes in consumption they induce, and if consumption changes over time, then instead of discounting total consumption impacts as the SRTP, one could calculate the direct impacts using another discount factor. The discussion above of the Sandmo-Dreze formulation is a case in point. These alternatives do not provide prescriptions, only alternative formulas for arriving at the same point.

The discrepancy between public evaluation of a marginal dollar to future generations, and individuals' own intertemporal evaluations can arise even in the case of very simple social welfare functions. Thus, assume that there is a utilitarian social welfare function, which simply adds up the utility of successive generations, and for simplicity, assume each generation lives for only two periods. The t^{th} generation's utility is represented by a

utility function of the form:

$$3A.5) U'(c_t^i, c_{t+1}^i)$$

where the first argument refers to consumption the first period of the individual's life, the second to consumption the second period. Then observed market rates of interest refer to how individuals are willing to trade off consumption over their own life. These may or may not bear a close correspondence to how society is willing to trade off consumption across generations. The former corresponds to u_2^i/u_1^i , while the latter corresponds to u^{t+1}_1/u^t_1 .

If the government has engaged in optimal intertemporal redistribution and does not face constraints in imposing lump sum (i.e. nondistorting) taxes on each generation, then the two will be the same, and equal to the marginal rate of transformation (in production, i.e. the return to investment). But whenever either of these conditions is not satisfied, then market rates of interest facing consumers (measuring their own marginal rates of substitution) need bear no close relationship to society's marginal rate of substitution across generations. Diamond and Mirrlees (1970, 1971) show that if the only reason for the discrepancy between producer and consumer interest rates is optimally determined commodity taxes, and there are no after-tax profits, possibly because there is a 100% pure profits tax, then the government should use the producer rate of interest. Stiglitz and Dasgupta (1971) have shown that this result does not hold if either of these assumptions is dropped.

Under certain circumstances (in particular the existence of optimal intergenerational lump sum transfers), asymptotically the producer rate of interest will equal the pure rate of time preference of society. More generally, when the government must resort to distortionary taxes, not only is this not true, but the rates of discount employed may reflect distributional considerations (see Stiglitz 1985).

Appendix 3B: Technical Notes on Discounting

The Social Welfare Function and Interpersonal Comparisons of Utility

Economists have long debated the equity of discounting distant future benefits (Ramsey, 1928; Mishan, 1975; Rawls, 1971; Sen, 1982). The standard approach to issues of equity since Bergson (1938) has been to summarize views about interpersonal equity in the form of a *social welfare function*, an algebraic formulation relating welfare to levels of consumption of the society's members at a given point in time and across time. Arguments about the choice among alternative social welfare functions then turn on the ability to derive a particular function from sound theoretical principles (seemingly

plausible axioms), and about the resulting reasonableness of its derived implications.

While all social welfare functions have been criticized for assuming interpersonal comparability of utility, there seems to be no way of addressing the ethical issues involved in making decisions affecting different generations without making some assumptions implicitly or explicitly about interpersonal comparability. Two polar views are represented by the utilitarian approach, in which social welfare is the sum of utilities; and the Rawlsian approach, in which social welfare reflects the welfare of the worst-off individuals. While the utilitarian approach can be derived from what many view as a persuasive axiomatic (theoretical) structure (Harsanyi, 1955), the Rawlsian approach is derived from a "max-min" strategy (maximize the minimum outcome for any given party) popular in game theory, but which itself does not rest on widely accepted axiomatic principles.

The Rawlsian max-min principle is the strongest in assuring (the least fortunate groups of) future generations levels of consumption at least as great as that of (the least fortunate groups of) the current generation. It is consistent with the Brown-Weiss (1989) approach noted above. The max-min criterion permits inequality in consumption between individuals (or in this case, between generations) only if it improves the position of the poorest. (For the remainder of this chapter, we shall simplify by ignoring inequality within a generation.) In the absence of technical change this would imply that consumption per head should be the same for all generations. By contrast, the utilitarian criterion allows, in principle, future consumption to fall below current consumption, provided the current generation is made sufficiently better off as a result. Correspondingly, it also allows for decreases in present consumption, provided the future generation is made sufficiently better off as a result.

The Rawls and utilitarian social welfare functions can be viewed as limiting cases of more general social welfare functions embracing social values of equality (Atkinson, 1971; Rothschild and Stiglitz, 1973). In practice, so long as there is sufficient scope for technological change, optimizing any egalitarian social welfare function over time yields increases in consumption per capita. Moreover, with any of the approaches, earlier generations are entitled to draw down the pool of exhaustible resources so long as they add to the stock of reproducible capital.

The individualistic social welfare function, accepted by most economists as the basis of ethical judgments, accepts individuals' own relative valuations of different goods. It does not place separate valuations on unequal access to particular goods, other than through their effects on the affected individuals. For example, Thurow (date) argued that income distribution is a public good, but that its value could be captured in individuals' valuations. Although this represents the consensus view, some economists have insisted that for particular goods, individuals' valuations need not be the basis of societal

1 valuations. For instance, Tobin (1970), in what he called specific egalitarianism, argued
 2 that society might argue for greater equality in distribution of health care than would be
 3 reflected in individuals' own evaluations. Most economists, however, reject this view.

4
 5 Sen (1982) similarly suggests a basis for not discounting when environmental effects are
 6 in question. He argues that a fundamental right of the future generation may be
 7 violated when the environment is degraded by the present generation, and that the
 8 resulting "oppression" of the future generation is inappropriate even if that generation is
 9 richer than the present and has a lower marginal utility of consumption. In this
 10 framework, intertemporal equity for environmental questions requires "a rejection of
 11 'welfarism,' which judges social states exclusively by their personal welfare
 12 characteristics."

13 14 Relation to Market Rates of Interest

15
 16 Economists have long recognized that a competitive market equilibrium yields a (Pareto)
 17 efficient outcome, under appropriate conditions (perfect competition, no externalities,
 18 etc.). The distribution of income that it yields, however, does not in general maximize
 19 any particular social welfare function. It is a well recognized function of government to
 20 intervene in the distribution of income, e.g. by establishing programs for the very poor.
 21 By the same token, the intertemporal distribution of welfare that emerges from the
 22 market will not, in general, maximize any particular social welfare function discussed in
 23 the preceding section. While it is a legitimate function of government to intervene to
 24 change the intergenerational distribution of welfare, there is no presumption that the
 25 government has in fact intervened so that the observed resource allocations are those
 26 that maximize intertemporal social welfare. --cp M on Nordhaus et al.--*** Moreover, in
 27 the case of climate change, no one government exists to make these decisions.

28
 29 In general, the market rate of interest--the relative price of consumption of one
 30 generation in one year of its life to consumption in another year--will not equal the
 31 SRTP. In standard life cycle models, even with no technological progress and an
 32 economy in steady state, there would be no discounting for society's purposes -- each
 33 generation is identical, so the marginal utility of consumption of each is the same.
 34 Nonetheless, the market rate of interest will be positive in any efficient equilibrium
 35 under certain reasonable assumptions about utility functions (such as individual
 36 impatience and zero bequest motive; Diamond, 1965). In such models the market rate of
 37 interest would thus always overestimate the SRTP. Under some special conditions, with
 38 governments intervening with non-distortionary taxation to optimally redistribute income
 39 across generations, then observed market rates of interest will accord with the SRTP.
 40 But these are highly specialized conditions. (See Stiglitz, 1985, Pestieau, 1972). The
 41 market rate of interest, of course, remains relevant, because it reflects the opportunity
 42 cost of capital; the changes in consumption generated by any change in policy will be

strongly affected by the opportunity cost of capital, as the discussion below will illustrate.

Treatment of Future Generations; Sustainable Development

The concern for fairness to future generations has long undergirded the environmental movement. This concern spans a broad range of political, social, and ethical considerations and viewpoints; a proper formal treatment poses special challenges to economic science. Perhaps best known among recent formulations, the report of the Commission on Environment and Development (United Nations, 1987), led by Norwegian Prime Minister Gro Harlem Brundtland, called for "sustainable development," defined as economic activity that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987; for a discussion of sustainable development, see sections 1.6 above and 3.6 below). Similarly, Brown-Weiss (1989, 25) has argued from the standpoint of international law that "each generation is entitled to inherit a planet and cultural resource base at least as good as that of previous generations."

A consensus exists among economists that this does not imply that future generations should inherit a world with at least as much of *every* resource; such a view would preclude consuming any exhaustible natural resource. The common interpretation is that an increase in the stock of capital (physical or human) can compensate for a decline in the stock of a natural resource. Under most calculations, given the savings rates of all but the lowest-saving countries in the world, most countries now pass this test of sustainability.

Economics has long recognized the concept of sustainability. Hicks (1938) used the idea in defining net national income. Neoclassical growth theory (Phelps 1961, Meade ~~date~~, Robinson 1962) advanced the idea of sustainability in its formulation of the "Golden Rule": that configuration of the economy giving the highest level of consumption per head that can be maintained indefinitely. A recent extension has proposed the "Green golden rule" (Beltratti, Chichilnitsky, and Heal 1993). The recent economic debate on sustainable development has focused on two issues: 1) intertemporal equity and 2) capital accumulation and substitutability.

Intertemporal equity. Robert Solow's definition (Solow, 1992) focuses on intertemporal equity: sustainable development requires that future generations be able to be at least as well off as current generations. Sustainable development does not preclude the use of exhaustible natural resources, but requires that any use be appropriately offset. Likewise, any environmental degradation must be offset by an increase in productive capital sufficient to enable future generations to obtain at least the same standard of living as those alive today.

Capital accumulation and substitutability. Solow's definition, and much of economic theory to date, implicitly assumes that substitutes exist or could be found for all resources. If substitution possibilities are high, as most evidence from economic history indicates, then no single resource is indispensable, and intertemporal equity stands as the only crucial issue (Pearce 1988). If on the other hand, human and natural capital are complements or only partial substitutes then different classes of assets must be treated differently, and some assets are to be preserved at all costs.

Some have argued that the future damages from global warming are on the order of 1 to 2 percent of GDP or less, whereas aggressive abatement costs are larger (Nordhaus, 1993). If this is the case, then taking costly actions now to mitigate global climate change later must rest on one of two arguments: First, that prudence calls for avoiding a large-scale experiment with the planet, and avoiding climate change lies beyond normal economic calculus; or second, that the potential exists for large, sudden, irreversible nonlinearities with major effects on the economy, particularly the economy of certain countries or regions.

Others have argued that if a longer time horizon is considered than that of the conventional benchmark of $2\times\text{CO}_2$, and if upper bound warming and damages are taken into account, and considering the range of estimates for abatement costs, then even a standard economic analysis using the social discounting approach outlined here can conclude that the benefits of aggressive action outweigh the costs on economic grounds (Cline, 1992). This result obtains even though technical progress permits future per capita incomes eventually to be much higher than present, because given conventional estimates of the elasticity of marginal utility, the intergenerational bargain of exchanging modest costs today for large avoided damages in the future remains attractive. In this case, the two considerations just noted simply reinforce this conclusion.

In many developing countries, Solow's definition would not be viewed as acceptable, since it seems to place no weight on their aspirations for growth and development. Further, formal models analyzing optimal development paths using a min-max (Rawlsian) criterion would, of course, focus exclusively on the welfare of the less developed countries in the first place (Note that in Rawls' formulation, $\theta = \infty$). But the prescription would be simple: massive redistribution from the North to the South immediately, without introducing the complication of long-term environmental problems. Even if there were limits on the transfers, it would suggest that all of the costs of mitigation--including those occurring within the South-- be borne by the North.

Of course, even the utilitarian approach ($\theta < \infty$) would tend to lead to higher general income transfers to poor countries than presently observed. Adherents of the descriptive approach would ask why the utilitarian construct is appropriate when considering intergenerational equity (as in the identification of the SRTP suggested in equation 3.1)

1 if it is not applied in practice across (or, for that matter, within) countries at the present.
 2 In one sense, this question is another application of the principle suggested above that in
 3 the absence of optimal redistribution intervention by the government, observed market
 4 rates (in this case of North-South transfers) will not necessarily or likely equal social
 5 rates. Alternatively, the equity norm suggested here may not be widely shared by
 6 governments or voters.

7
 8 Some might seek to explain the paucity of present-day North-South transfers on grounds
 9 of incentive effects. Thus, the massive marginal tax rates on the North that would be
 10 required to equalize income levels with the South could seriously reduce the amount of
 11 output available for redistribution. Perhaps more relevant (in view of the modest but
 12 unfulfilled international targets for grant aid), the problems of still unaddressed poverty
 13 within the North and sharp inequality within many developing countries complicate
 14 attempts to improve overall welfare through North-South transfers. The fundamental
 15 explanation, however, is that each country tends to consider primarily the welfare of its
 16 own citizens, and only secondarily that of others.

17
 18 Despite the political constraints on present-day North-South transfers that would
 19 otherwise be recommended by the utilitarian approach, the time-discounting concepts of
 20 that approach, and the SRTP in particular, remain valid subject to these constraints.
 21 Thus, consider a matrix with two rows -- North and South -- and two columns -- present
 22 and future. The SRTP can appropriately be applied between the two columns along
 23 each row, even if there is a barrier to its application between the two rows. Leaders and
 24 publics in developing countries have cause for concern about their descendants just as do
 25 their counterparts in developed countries. As noted above, however, the value of the
 26 SRTP is likely to be higher for the South row than for the North row.

27
 28 At the same time, both the Rawlsian and utilitarian approaches imply that the South
 29 should actively engage in mitigation financed by transfers from the North, so that
 30 efficient mitigation can be obtained. Any Pareto efficient development path (including
 31 any reasonable definition of sustainable development) must have this property of
 32 efficient mitigation. Thus, the level of mitigation should be set based on the eventual
 33 target of greenhouse gas stabilization and implied levels of world emissions (without
 34 regard to where those emissions originate). The magnitudes of actions required to attain
 35 those levels of world emissions will, of course, depend on the rates of growth of the less
 36 developed countries as well as the increased energy efficiency among both the developed
 37 and developing countries.

38 39 Adjustments to the Discount Rate

40
 41 **Impatience.** In a society in which income levels are not expected to rise, impatience may
 42 still cause a household (or the present generation) to discount the future (generation),

that is, to equate a smaller amount of consumption today with a larger amount in the future. In his classic paper on optimal saving, Ramsey (1928, p. 543) judged that any allowance for pure time preference ($\rho > 0$) "is ethically indefensible and arises merely from the weakness of the imagination." Correspondingly, he argued that future generations should have equal standing with the current generation; there was no moral or ethical basis for weighing the welfare of future generations less than that of the current generation.

For an individual, some non-zero value of pure time preference can make sense, because he or she has a finite life and thus uncertainty about being alive to enjoy future consumption. Nonetheless, for a life span of 70 years, pure time preference at even 1 percent per annum implies that consumption at the end of life is worth only half that at the beginning. Evidence also suggests that individuals' discount rates can change over time, with lower discount rates being used for longer time horizons (Thaler and Lowenstein 1989).

Considerations for society as a whole are different. The approach described earlier asks: if society values different generations in a particular way (the social welfare function), how should changes in consumption in different generations be compared? How society values different generations can be viewed then from two different perspectives: 1) How should society value different generations (an ethical approach); or 2) How does the current generation value the consumption of future generations. Ramsey's analysis focused on the ethical presumption that consumption by all generations should have equal value. But this does not exclude the possibility that as a matter of description the current generation gives less value to consumption of future generations.

-- * summarize in main text? ***--Discounting for Rising Levels of Consumption and Utility.** In equation 3.1, $SRTP = \rho + \theta g$, the second term on the right-hand side raises two questions. First, what are reasonable expectations concerning increases in per capita income (growth rate g in the equation)? Second, how should intertemporal differences in expected consumption per capita be translated into social weights, that is, marginal valuations of dollars of future income. This second question refers to the parameter θ , the elasticity of marginal utility. This parameter essentially tells how rapidly the additional utility from an extra unit of consumption drops off as consumption rises.

No consensus on the first question has emerged. The low levels of productivity increase over the past two decades have raised the question: were the high rates of technological change experienced in the decades following World War II an aberration? Or are the low rates experienced from 1973 until 1993 an aberration?

While it is also the case that no consensus has emerged on the answer to the second

question, there is a generally accepted method for approaching the issue. The evaluation of any individual's consumption can be summarized by a utility function of the form $U = U(c)$ where the parentheses indicate that U , utility, is a function of c , per capita consumption. Marginal utility is positive ($U'(c) > 0$), but it declines as consumption rises ($U''(c) < 0$). That is why if consumption of some future generation is higher, the marginal valuation of its consumption will be lower. The question is, how much lower? Formally, the answer is given by the elasticity of marginal utility (θ) or: $[dU'/U']/[dc/c]$.

Individuals in their day-to-day decision making reveal information about their perceptions concerning their own utility functions, in at least two different contexts: behavior towards risk and intertemporal allocation of consumption. In both contexts, there seems to be a consensus on elasticities of marginal utilities in the range of 1 to 2, even though the empirical studies require strong assumptions about the specific form of the utility function (symmetric and time-separable).

Thus, one of the most commonly used utility functions, logarithmic utility, implies $\theta = 1$, meaning that if income rises by 1% the marginal utility of consumption falls by 1%. Attempts to estimate this elasticity by Fellner (1967) and Scott (1989) both place it somewhat higher, at 1.5; whereas recent estimates reviewed by Pearce and Ulph (1994) place it in the vicinity of 0.8.

Just as the choice of the rate of pure time preference (ρ) has important implications for intergenerational equity, as discussed above, so does the choice of the elasticity of marginal utility. The more weight the society gives to intergenerational equity, the higher the value of θ . Thus, a value of, say, 3, would mean that it would require a 30 percent rise in the next generation's per capita consumption to warrant a 10 percent reduction in that of the present generation; or, under a bleaker outlook, that if the future generation is expected to be poorer than the present, the present would be prepared to accept a 30 percent reduction in consumption to secure a 10 percent increase in that of the future generation (so long as the two relative consumption levels did not reverse). Even a unitary value is equity oriented, however. When $\theta = 1$, a 10 percent reduction in the richer generation's income will be an acceptable trade-off for a 10 percent increase in that of the poorer generation, even though the absolute reduction of the one exceeds the absolute increase of the other (because the absolute consumption base of the one is larger than that of the other)³.

Discounting for Risk. The standard treatment of risk in models involving impacts over a single individual's life is not to raise the discount rate for riskier projects, but instead to convert probabilistic consumption patterns into their certainty equivalents and then discount the results at the standard rate. The same should be true for the pure time preference component of the SRTP when discounting across generations. This component should remain unchanged with respect to risk, and the influence of risk

1 should be incorporated in the stream of expected consumption effects instead.

2
3 There would seem to be an argument for varying the growth-based component of the
4 SRTP with respect to risk, however. If there is uncertainty about the rate of per capita
5 income growth, g , then consider the effect on the component θg in the SRTP. Suppose
6 there are two scenarios each with 50 percent probability: per capita income growth of 1
7 percent and per capita growth of 2 percent. There will be two resulting possible streams
8 of marginal utility over time. The stream of expected value of marginal utility will be
9 the average of these two streams. But if marginal utility is a convex function of
10 consumption⁴, this average will be greater than the stream of marginal utility generated
11 by considering the simple average growth rate over time, 1.5 percent. That is, with
12 diminishing marginal utility, at any point in time marginal utility along the path for 1.5
13 percent growth will be closer to that of the 2 percent growth path than to that of the 1
14 percent growth path. Correspondingly, the expected marginal utility path lying halfway
15 between the two scenarios will coincide with the marginal utility stream for a growth rate
16 closer to 1 percent than to 2 percent. Essentially, the expected value of marginal utility is
17 greater than the marginal utility of expected income. On this basis, there would be
18 grounds for reducing the growth-based component of the SRTP under circumstances of
19 risk. Because the risk in predicting per capita growth on centuries-scale horizons is high,
20 this consideration is particularly relevant for the problem of global warming.

21
22 Fourth, issues of discounting involve the relative values of goods at different dates, and
23 thus intertemporal pricing. Issues of pricing of risk need to be carefully separated out
24 from those involving intertemporal pricing. The standard procedure for conventional
25 models, involving impacts over a single individual's life, involves converting probabilistic
26 consumption patterns into their certainty equivalents, and then discounting at the social
27 rate of time preference -- not the incorporation of an incremental component into the
28 discount rate itself. This procedure does not, however, deal adequately with
29 uncertainties about future rates of growth of per capita income. Such uncertainties are
30 much greater over centuries-scale horizons.

31 Fifth, issues of equity can be treated in a way analogous to those of risk, through the use
32 of certainty equivalents (Atkinson 1970, Rothschild and Stiglitz 1974), though the likely
33 effect on the appropriate rate of discount have yet to be thoroughly studied.

34
35
36 **Discounting Utility for Empathic Distance.** Rothenberg (1993) and Schelling (1993)
37 have suggested that although non-zero pure time preference might make sense for an
38 initial two or three decades, beyond a certain future point it makes no sense to apply
39 further discounting of consumption for pure time preference. Thus: "as the future
40 recedes... single generations come to be perceived more and more as homogeneous
41 entities (Rothenberg). Similarly: "time may serve as a kind of measure of
42 distance....Beyond certain distances there may be no further depreciation for time,

1 culture, geography, race, or kinship" (Schelling). A graph of the fraction of face value
 2 accorded to each successive generation (for constant real consumption) would thus be a
 3 series of declining, successively shallower steps that eventually reach a horizontal plateau.
 4 A deep plateau signifies major discounting for empathic distance; a horizontal line
 5 beginning and remaining at unity is the zero pure time preference rate across
 6 generations recommended by Ramsey. Policy based on empathetic distance (a shelf
 7 lower than unity) may be more defensible in a normative sense when the action is
 8 refraining from conferring a windfall gain (as in penurious aid budgets) than when it
 9 involves the imposition of windfall damage (as in global warming's effects on future
 10 generations).

11
 12 **Discounting Utility for Human Extinction.** One argument focuses on the fact that there
 13 is no absolute certainty that future generations will exist since any number of
 14 catastrophic events could occur. This argument, which might be called the "asteroid
 15 effect," might argue that it would make no sense to give up consumption today for the
 16 generation 200 years from now because it may not come into existence. Some
 17 economists believe it is appropriate for this reason to discount future consumption to
 18 reflect the inherent uncertainty in future conditions. However, the probability of human
 19 extinction would seem sufficiently small (especially within a time frame of two to three
 20 centuries) that the quantitative magnitude of discounting for this purpose is likely to be
 21 extremely small.

22
 23 Thus, according to some estimates the probability that an individual will die because an
 24 asteroid hits the earth during his or her lifespan is of the same order of magnitude as the
 25 probability that he or she will die in an airplane crash (about one in ten thousand). The
 26 chances of earth's collision with an asteroid large enough to cause species extinction
 27 (such as the 10-km-diameter object believed by some to have caused the
 28 Cretaceous/Tertiary dinosaur extinction) is far smaller (Wetherill and Shoemaker, 1982).
 29 However, to be generous to the extinction argument and for purposes of illustration,
 30 consider the individual risk at one in 10,000. The three-century horizon appropriate for
 31 global warming analysis is about four life spans, so set the probability of asteroid impact
 32 over this period at $1/2,500$, for purposes of illustration. Then at the end of this period, a
 33 given economic effect should be discounted enough to shrink its value by one- 2,500th.
 34 The discount rate required for this shrinkage is vanishingly small ($= 0.133 \times 10^{-4}$ percent
 35 per annum).

36
 37 Perhaps one reason the optimal growth literature includes discounting for extinction is
 38 that most of the literature emerged during the cold war, when nuclear annihilation was
 39 more plausible than today. For public policy purposes, even under those conditions it is
 40 arguably inappropriate to incorporate analytical assumptions that take as a premise the
 41 failure of policy (breakdown into nuclear war). In any event this motive for
 42 extinction-based discounting would seem even less appropriate for the future.

Discounting Utility for Acceptable Optimization Results. Another argument for non-zero pure time preference is that setting the rate at zero could imply that the present generation should accept near-starvation consumption levels, and correspondingly low utility, because with even very small returns on investment, an endless stream of future generations could enjoy increased consumption and (to a lesser degree) utility as a result.

To some extent, however, this concern is already addressed in the overall discount rate equation (3.1). As noted, the first term in that equation discounts utility (pure time preference), but the second term additionally discounts consumption to take account of falling marginal utility. The present generation is protected against an optimizing program setting its consumption near zero if the term for elasticity of marginal utility (θ) is large enough and marginal utility drops off fast enough to rule out impoverishment of the present generation for gains to future generations.

More fundamentally, a basic concern about zero pure time preference has to do with the mathematics of maximization over an infinite time horizon. If the utility function has no upper limit, any savings-investment optimization problem is not well defined, because the sum of utilities over time is infinite. There is some literature (Weizsacker 1965) proposing criteria (the "overtaking criterion") to address this problem, but the implications of these criteria for climate policy have not been examined.

Even when the optimization problem is made well-defined, for the purposes here, e.g., if there is an upper bound to utility (as in the function in annex equation 3A.3), there is a tendency toward knife-edge results, with one extreme outcome for zero pure time preference and the opposite extreme for non-zero rates. Thus, whereas the concern of Koopmans (1965), Mirlees (1974), and Chakravarty (1969) is that zero pure time preference can suppress current consumption to unacceptably low levels, just the opposite result can be reached in optimization models that take exhaustible resources into account. In some specifications of such models (Dasgupta and Heal, 1974; Solow, 1974a), any pure time preference rate in excess of zero generates the unacceptable result that optimal consumption falls to zero over the very-long term (although Stiglitz, 1974, shows that this awkward conclusion is not robust with respect to alternative assumptions about technological change, production functions, and utility functions).

Knife-edge results can of course result from other properties of utility maximization models as well (depending, for example, on whether the production function has non-unitary elasticity of substitution between factors, or whether capital-augmenting technical change is zero or positive). Focusing on the mathematical and knife-edge complications of optimization approaches, they do not go far toward specifying the proper magnitude for the rate of pure time preference, even though they might be seen as providing a set of arguments that the rate is greater than zero. Thus, considering the infinite horizon in such models, an infinitesimally small but non-zero rate of pure time

1 preference could suffice to avoid prejudicing the optimal consumption path against the
2 present generation, depending on other assumptions of the model.

3
4 Another attack on very low discount rates is provided by those models concluding that
5 low discount rates imply unreasonably high savings rates, particularly in poor economies.
6 Only by raising the discount rate to higher, "more reasonable" numbers can savings rates
7 of the kind actually observed be obtained (e.g. Mirlees, 1967; Chakravarty, 1969). This
8 illustrates a general problem with models founded on utilitarianism: they may imply very
9 large sacrifices from one generation or other group. This argument also assumes that
10 the model captures accurately the structure of the economy; typically, however, these
11 models imply much higher rates of return on capital than are in fact observed in
12 LDCs. For example, Chakravarty (1969) assumes constant return on capital at 33
13 percent. Instead, the small differences between advanced and developing countries in
14 observed rates of return in spite of large differences in capital-labor ratios suggests either
15 that the economies are not on the same production function, or that the constant returns
16 to scale production function models employed are inappropriate. (See Stiglitz, 1988,
17 Lucas, 1988).

18 19 Producer or Consumer Interest Rates?

20
21 *****summary should go in main body*****

22 A large literature has debated whether, for small changes in consumption levels,
23 observed rates of interest provide the appropriate basis of trading off government
24 expenditures and changes in consumption of individuals of different generations at
25 different dates. In a world in which there was no taxation, no market distortions, and a
26 single individual living forever (or else "dynastic" utility functions in which individuals
27 take full account of their descendants' welfare), society's intertemporal discount rate
28 should presumably correspond to that of the representative individual, and his trade-offs
29 across time would be given by the market rate of interest.

30
31 But these assumptions are not generally satisfied, as evidenced by the marked
32 discrepancy between the lower interest rates on savings typically facing consumers and
33 the higher rates earned on investments by producers.

34
35 Part of the source of the frequent confusion about appropriate discount rates is a
36 confusion about what is being discounted. In the social discount rate approach, what is
37 being discounted is changes in consumption at different dates. Typically, in the producer
38 interest rate approach, what is being discounted are the direct cash flows from the
39 project. The two need not be inconsistent; under certain conditions, using producer
40 interest rates in evaluating direct cash flows and using the social discount rate in
41 evaluating changes in consumption will give the same results -- but only under the
42 specialized conditions specified earlier.

Four schools of thought have emerged on the proper discount rate for public policy. One suggests that it should be the producer interest rate, representing the private rate of transformation between investment today and output in the future; one, the consumer interest rate; one, that it should be some combination of the two; and one, that it should have nothing to do with either. In the absence of any non-distortionary intertemporal social welfare maximization by the government, we have already noted the general result that the rate of discount should be neither.

In special cases, however, one of the other three schools of thought may be correct. For instance, if the government were comparing two projects, both of which cost the same, and both of which yielded their output in the same year, then a comparison of the rates of return would provide an appropriate basis of choosing among projects. Cline (1992) proposes a shadow price of capital set equal to the present discounted value of an annuity paying equal annual installments over a lifetime of N years (set at 15 years for the lifetime of typical capital equipment), with a return of r equal to the rate of return on capital, and discounted at the social rate of time preference (SRTP). With plausible ranges for N , r , and $SRTP$, the shadow price of capital tends to be in the range of 1-1/2 to 2 units of consumption equivalent per unit of capital.

If a public project displaced a private project of equal cost, the same reasoning would imply that the government should only undertake the public project if the rate of return exceeded the rate of return in the private sector (Stiglitz, 1982). More generally, when the government undertakes a project, complex general equilibrium effects can be expected. The full consumption effects of these changes (or their consumption equivalents) need to be calculated, and then discounted using the SRTP (Arrow and Kurz, 1970; Feldstein, 1970; Bradford, 1975; Stiglitz, 1982). Implementation of this approach can apply a shadow price of capital to convert all investment effects into their (magnified) consumption equivalents, and then apply the social rate of time preference for consumption to discount the resulting stream of consumption equivalents (Lind, 1982; Gramlich, 1990). A shadow price of capital greater than unity reflects the fact that the rate of return on capital exceeds the SRTP; care must be exercised in evaluating the shadow price and its path over time (Cline, 1992).

Sometimes, as just discussed, one can look at the direct expenditures and apply an adjusted discount factor, the public sector discount rate. There is a large literature emphasizing different aspects of the adjustment methodology. One body of literature emphasizes the effects on consumption versus investment, deriving a weighted average of the consumption and investment rates of return, with weights depending on the respective importance of the sources of finance (Sandmo and Dreze, 1971). Within the literature on optimal taxation and production (where the discrepancy between producer and consumer rates of interest arises from optimally determined tax rates), if the government is relatively unrestricted in the set of commodity taxes that it can impose,

the producer rate of interest should be used to discount (Diamond and Mirrlees, 1971; Pestieau, 1974). However, in the more relevant regime in which government faces constraints on the sets of taxes that are imposed, there is no simple relationship between the appropriate public sector discount rate and the producer interest rate (Stiglitz and Dasgupta, 1971, Stiglitz, 1985, 1988).

Discounting Environmental Impacts

The essence of social discounting is to convert all effects into their consumption equivalents at the proper relative prices, and then to discount the resulting stream of consumption equivalents at the social rate of time preference. Incorporating environmental effects thus does not change the SRTTP itself, but requires special attention to the proper relative pricing of environmental goods over time. While there is a generally accepted approach to valuing goods, there is less consensus concerning valuation of environmental impacts, other than those valued solely for their impacts on the production of goods. The question is addressed within the public finance literature in terms of the valuation of public goods. Assume consumers have utility functions of the form $U = U(c, G)$ where G is some public good (e.g., quality of the environment). Then marginal rates of substitution between c at different dates may bear no correspondence to marginal rates of substitution between G at different dates. This implies that there is no justification for discounting environmental degradation at market rates of interest. The appropriate procedure entails converting the environmental change into contemporaneous consumption benefits, and discounting those.

Technical progress and structural change over the past several decades have resulted in improvements in several measures of environmental quality in the developed countries (World Bank 1992). Moreover, recorded reserves of many "exhaustible resources" have actually increased over the last century, accompanied by a fall in their real prices. This provides evidence that continued growth in per capita incomes will result in improved environmental quality in at least some dimensions. Some have supposed, however, that environmental degradation will occur as society grows (Weitzman 1993). If this occurs or, more likely, if the environment is an income elastic good on which people are willing to spend relatively more as their income rises, then the marginal rate of substitution between environmental quality and private goods will systematically change over time, toward a higher relative marginal value of the environment. The result equivalent to using a low (or even negative) discount rate for environmental amenities (see annex 3A), with prices unchanged. However, it is important to reiterate that this process involves properly valuing future environmental benefits in arriving at the future flow of consumption, and does not change the appropriate discount rate itself at which the consumption stream should be discounted.

Much of the environmental literature critical of cost-benefit analysis, in contrast, argues

for a zero discount rate without seeming to recognize the distinction between a zero rate of pure time preference (ρ) and a zero social rate of time preference (SRTP; see, e.g., Daly and Cobb, 1991; Norgaard and Howarth, 1991). But from equation 3.1, so long as consumption growth is positive there will be a nonzero SRTP. Similarly, some modern philosophers make the same mistake (e. g. Parfit, 1984; Cowen and Parfit, 1992).

Finally, there has been considerable discussion about the proper discounting method for environmental projects of institutions such as the Global Environmental Facility of the World Bank (see e.g. Munasinghe, 1993). The method that follows from the social cost-benefit approach is to obtain consumption equivalents of the environmental effects over time and then discount at the SRTP. The consumption equivalents of carbon emissions, for example, can be evaluated by applying the carbon shadow price from models of global warming damage and optimal abatement, so long as those models themselves are implemented with discounting based on appropriate values for the rate of pure time preference and the elasticity of marginal utility (Cline, 1993). Within a fixed institutional investment budget, it may be that the collection of potential projects that successfully passes a cost-benefit test on this basis more than exhausts available funds. If so, efficient trade-offs within the menu of projects will appropriately involve cutoffs at a higher shadow price in funds drawn from the institutional budget -- but always with benefits evaluation based on the consumption equivalence principle just outlined.

NOTES

1. Such results are consistent with standard life cycle models, without government intervention. On the other hand, they are not consistent with dynastic models, in which each generation incorporates into its own utility function the utility of future generations in a manner exactly analogous to the way future generations are incorporated into the social welfare function (Barro date). However, considerable evidence weighs against Barro's hypothesis.

2. For an open economy, the elasticity-adjusted rate on foreign loans also enters the calculus. However, for analysis of a global issue, this extension is probably inappropriate, as globally the economy is closed.

3. With a non-utilitarian social welfare function, social welfare may be written in the form, e.g.,

$$S = G(U(C)).$$

If $G = U$, then it is clear that the rate at which social marginal utility diminishes with increases in consumption may differ from the rate at which private marginal utility diminishes, so that evidence about the latter is only partially relevant for the former.

4. There is a strong consensus within the economics profession that individual's marginal utility is convex. The behavioral implications with respect to risk of the assumption that $U'' < 0$ are consistently rejected by the data (it would imply, in particular, that absolute risk aversion strongly increases with consumption).

References

Arrow, K.J. 1982. "The Rate of Discount on Public Investments with Imperfect Capital Markets," in Lind 1982.

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

Atkinson, A.B., 1970. "On the Measurement of Inequality" in Journal of Economic Theory. 2: 244-63.

Bergson, A., 1938. "A Reformulation of Certain Aspects of Welfare Economics" in Quarterly Journal of Economics. 52: 310-334.

Birdsall, N. and Steer, A. 1993. "Act Now on Global Warming -- But Don't Cook the Books," Finance and Development, 30(1), pp. 6-8.

Bradford, D.F., 1975. "Constraints on Government Investment Opportunities and the Choice of Discount Rate" in American Economic Review 65(50): 887-899.

Broome, J., 1992. Counting the Costs of Global Warming, Cambridge: White Horse Press.

Brown-Weiss, E., 1989. In Fairness to Future Generations: International Law. Common Patrimony, and Intergenerational Equity, Tokyo: University Nations University.

Chakravarty, S., 1969. Capital and Development Planning. Cambridge MIT Press.

Chichilnisky, G., 1994. "Global Environmental Risks and Financial Instruments" in G. Pillet and F. Gassmann (eds.). Toward a Decision Making Framework to Address Climate Change. Report of the IPCC Working Group III Writing Team II Montreux Meeting, March 3-6. Switzerland: Wurenligen & Villigen. Paul Scherrer Institute.

Chichilnisky, Graciela, 1994. "What is Sustainable Development?" (New York: Columbia Univ., mimeogr.)

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

Cline, W.R., 1993. "Modelling Economically Efficient Abatement of Greenhouse Gases". Paper presented at the United Nations University Conference on "Global Environment, Energy and Economic Development", September 1993. Tokyo.

- 1 Cowen, T. and D. Parfit. 1992. "Against the Social Discount Rate" in P. Laslett and J.
2 Fishkin (eds.), *Philosophy, Politics and Society: Series VI, Future Generations*. Yale
3 University Press.
- 4
- 5 Daly, H.E. and J.B. Cobb. 1989. *For the Common Good*. Boston MA: Beacon Press.
- 6
- 7 Dasgupta, P., S. A. Marglin, and A. K. Sen, 1972. *Guidelines for Project Evaluation*
8 (New York: UNIDO)
- 9
- 10 Dasgupta, P., and G.M. Heal, 1974, "The Optimal Depletion of Exhaustible Resources"
11 in *Review of Economic Studies*, Symposium.
- 12
- 13 Diamond, P.A., 1965, "The Evaluation of Infinite Utility Streams," in *Econometrica* 33:
14 170. [chk AER?: National Debt in a neoclassical growth model. AER. 55: 1126-50/]
- 15
- 16 Diamond, P., and J. Mirrlees, 1971. "Optimal Taxation and Public Production. I and II,"
17 *American Economic Review*, vol. 61 (March and June), pp. 8-27 and 261-278.
- 18
- 19 Feldstein, M.S., 1970. "Financing in the Evaluation of Public Expenditure". Discussion
20 Paper No. 132. Cambridge MA: Harvard Institute for Economic Research (August).
- 21
- 22 Fellner, W., 1967. "Operational Utility: The Theoretical Background and a
23 Measurement" in *Ten Economic Studies in the Tradition of Irvina Fisher*. New York:
24 John Wiley and Sons.
- 25
- 26 Gramlich, E.M., 1990. *A Guide to Cost-Benefit Analysis*. Second Edition. Englewood
27 Cliffs NJ: Prentice Hall.
- 28
- 29 Harberger, Arnold C., 1973. *Project Evaluation: Collected Essays* (Chicago: Markham)
- 30
- 31 Harsanyi, J.C., 1955. "Cardinal Welfare, Individualistic Ethics, and Interpersonal
32 Comparisons of Utility" in *Journal of Political Economy*. 63: 309-321.
- 33
- 34 Hicks, J.R. 1938. Value and Capital, London: publisher.
- 35
- 36 Howarth, R. B., and R.B. Norgaard, 1992. "Environmental Valuation under Sustainable
37 Development," *American Economic Review* vol. 82: pp. 473-477.
- 38
- 39 Ibbotson, R.G., and Brinson, G.P. 1987. Investment Markets. New York: McGraw-Hill,
40 updated in Nordhaus 1994.
- 41
- 42 Intergovernmental Panel on Climate Change. 1990a. *Climate Change*, the IPCC

1 Scientific Assessment. Report from Working Group I. Cambridge: Cambridge University
2 Press.

3
4 Koopmans, T.C., 1960. "Stationary Ordinal Utility and Impatience" in *Econometrica* 28:
5 287-309.

6
7 Koopmans, T.C., 1966. "On the Concept of Optimal Economic Growth," in *Econometric*
8 *Approach to Development* (Illinois: Rand McNally)

9
10 Lind, R.C., ed., 1982. *Discounting for Time and Risk in Energy Policy*. Washington DC:
11 *Resources for the Future*.

12
13 Lind, R.C. 1994. "Intergenerational Equity, Discounting, and the Role of Cost-benefit
14 Analysis in Evaluating Global Climate Policy," in Nakicenovic, et al., eds.

15
16 Little, I. M. D., and J. A. Mirrlees, 1974. *Project Appraisal and Planning in Developing*
17 *Countries* (London: Heinemann)

18
19 Lucas, R. "On the Mechanics of Economic Development," *Journal of Monetary*
20 *Economics*, July, vol. 22, no. 1, pp. 3-42.

21
22 Manne, A.S., R. Mendelsohn, and R.G. Richels, 1993. "MERGE- A Model for
23 Evaluating Regional and Global Effects of Greenhouse Gas Reduction Policies". Mimeo.
24 Electric Power Research Institute, Palo Alto CA.

25
26 Manne, A.S., "The Rate of Time Preference: Implications for the Greenhouse Debate,"
27 in Nakicenovic et al. 1994.

28
29 Mirrlees, J. A., 1967. "Optimum Growth when Technology is Changing" in *Review of*
30 *Economic Studies* 34: 95-124.

31
32 Mishan, E.J., 1975. *Cost Benefit Analysis: An Informal Introduction*. London: Allen &
33 *Unwin*.

34
35 Munasinghe, M., 1993. *Environmental Economics and Sustainable Development*.
36 Washington DC: World Bank.

37
38 Nakicenovic, N., W.D. Nordhaus, R. Richels, and F.L. Toth, eds. 1994. Integrative
39 Assessment of Mitigation, Impacts, and Adaptation to Climate Change: Proceedings of a
40 Workshop held on 13-15 October 1993. Laxenburg, Austria: International Institute of
41 Applied Systems Analysis.

- 1 Nordhaus, W. D., 1994. Managing the Global Commons: The Economics of Climate
2 Change. Mimeo. Cambridge, MA: MIT Press.
- 3
- 4 Nordhaus, W.D., 1993b. "Reflections on the Economics of Climate change" in Journal of
5 Economic Perspectives. 7(4): 11-25.
- 6
- 7 Nordhaus, W.D., 1993c. "Climate and Economic Development: Climates Past and
8 Future" in Annual Conference on Development Economics. Washington DC: World
9 Bank.
- 10
- 11 Nordhaus, W.D., 1991. "To Slow or not to Slow: The Economics of the Greenhouse
12 Effect" in Economic Journal 101(407): 920-937.
- 13
- 14 Parfit, D., 1983. "Energy Policy and the Further Future: the Identity Problem, " in D.
15 MacLean and P.G. Brown, eds., 1983. Energy and the Future (Totowa, New Jersey:
16 Rowman and Littlefield, PP. 38-58)
- 17
- 18 Pearce, D.W., and D. Ulph, 1994. "Estimating a Social Discount Rate for the United
19 Kingdom", Mimeo. Centre for Social and Economic Research on the Global
20 Environment, University College London and University of East Anglia.
- 21
- 22 Peck, S.C. and T.J. Teisberg, 1992. "CETA: A Model for Carbon Emissions Trajectory
23 Assessment" in Energy Journal 13(1): 55-77.
- 24
- 25 Pestieau, P. M., 1974. "Optimal Taxation and the Discount Rate for Public Investment in
26 a Growth Setting," Journal of Public Economics vol. 3, pp. 217-35.
- 27
- 28 Pohl, G., and D. Mihaljek (1989), "Project Evaluation in Practice," unpublished paper,
29 World Bank (December), quoted in Richard N. Cooper, Environmental and Resource
30 Policies for the World Economy, Washington, D.C.: Brookings Institution, 1994.
- 31
- 32 Pscharopoulos, George (1985), "Returns to Education: A Further International Update and Implications,"
33 Journal of Human Resources 20 (fall), 583-604, cited in Nordhaus (1994).
- 34
- 35 Ramsey, F.P., 1928. "A Mathematical Theory of Saving". in Economic Journal 138(152): 543-559.
- 36
- 37 Rawls, J., 1971. A Theory of Justice. Cambridge MA: Harvard University Press.
- 38
- 39 Rothenberg, J., 1993. "Economic Perspectives on Time Comparisons" in C. Nazli., ed., Global Accord:
40 Environmental Challenges and International Responses. Cambridge MA: MIT Press.
- 41
- 42 Rothschild, M., and J.E. Stiglitz, 1973. "Some Further Results in the Measurement of Inequality" in Journal
43 of Economic Theory. 6: 188-204.
- 44

- 1 Sandmo, A., and J.H. Dreze, 1971, "Discount Rates for Public Investment Under Uncertainty" in
2 International Economic Review 2: 169-208.
3
- 4 Schelling, T.C., 1993. "Intergenerational Discounting". Mimeo. University of Maryland, College Park
5 (November).
6
- 7 Schmalensee, R., 1993. "Symposium on Global Climate Change" in Journal of Economic Perspectives. 7(4): 3-
8 10.
9
- 10 Scott, M.F., 1989. A New View of Economic Growth. Oxford: Clarendon Press.
11
- 12 Sen, A., 1982. "Approaches to the Choice of Discount Rates for Social Benefit-Cost Analysis" in R. Lind et
13 al., eds., Discounting for Time and Risk in Energy Policy, 325-53. Washington DC: Resources for the
14 Future.
15
- 16 Sen, A., 1967. "Isolation, Assurance and the Social Rate of Discount" in Quarterly Journal of Economics 81.
17 no pages given
18
- 19 Solow, R., 1974a. "Intergenerational Equity and Exhaustible Resources" in Review of Economic Studies,
20 Symposium.
21
- 22 Solow, R., 1974b. "The Economics of Resources or the Resources of Economics" in American Economic
23 Association: Papers and Proceedings 64(2): 1-14.
24
- 25 Solow, R., 1992. "An Almost Practical Step Toward Sustainability," Washington: Resources for the Future.
26
- 27 Stiglitz, J.E., 1988. "Economic Organization, Information and Development" in H. Chenery and T.N.
28 Srinivasan, eds., Handbook of Development Economics. 94-160. Elsevier Science Publishers.
29
- 30 Stiglitz, J.E., 1985. "Inequality and Capital Taxation." Mimeo. IMSSS Technical Report #457. Stanford
31 University. (July).
32
- 33 Stiglitz, J.E., 1982. "The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best" in
34 R. Lind et al., eds., Discounting for Time and Risk in Energy Policy. 151-204. Washington DC: Resources for
35 the Future.
36
- 37 Stiglitz, J.E., 1974. "Growth with Exhaustible Resources: Efficient and Optimal Paths" in Review of Economic
38 Studies, Symposium.
39
- 40 Stiglitz, J.E., and P. Dasgupta, 1971. "Differential Taxation, Public Goods, and Economic Efficiency" in The
41 Review of Economic Studies 37(2): 151-174.
42
- 43 Sundquist, E.T., 1990. "Long-Term Aspects of Future Atmospheric CO₂ and Sea-Level Changes". in R.R.
44 Revelle et al., Sea-Level Change. National Research Council, Washington DC: National Academy Press.
45
- 46 Tobin, James, 1970. "On Limiting the Domain of Inequality," Journal of Law and Economics, vol. 13, no. 2,
47 October, pp. 263-77.
48
- 49 United Nations, 1987. Our Common Future. Commission on Environmental Development. (Brundtland
50 Report).

1 Weitzman, M.L. 1993. "On the Environmental Discount Rate," Journal of Environmental Economics and
2 Management, v. 26, no. 2, pp. 200-209.

3
4 Weizsacker, C.C. von, 1965. "Existence of Optimal Programs of Accumulation for an Infinite Time Horizon"
5 in Review of Economic Studies 32: 85-104.

6
7 Wetherill, G.W., and E.M. Shoemaker, 1982. "Collision of Astronomically Observable Bodies with the Earth"
8 in Leon Silver et al., Geological Implications of Impacts of Large Asteroids and Comets on the Earth,
9 Boulder, CO: Geological Society of America.

10
11 Phelps, E. 1961. "The Golden Rule of Accumulation: A Fable for Growth Men." American Economic
12 Review 51, September, pp. 638-43.

13
14 Meade, J. **Golden Rule article**

15
16 Robinson, J. 1962. "A Neo-classical Theorem." Review of Economic Studies 29, June, pp. 219-226.

17
18 Beltratti, A., G. Chichilnisky, and G. Heal, 1993. "Sustainable Growth and the Green Golden Rule." National
19 Bureau of Economic Research, Working Paper 4430, August, 29 pp.

20
21 Thaler and Lowenstein 1989.

IPCC

cc: SK

OFFICE OF THE U.S. GLOBAL CHANGE
RESEARCH PROGRAM
300 D Street, S.W., Suite 840, Washington, D.C. 20024

PHONE: (202) 651-8250/8240
FAX: (202) 554-6715/6858
e-mail: office@usgcrp.gov

TO: Lead Authors of IPCC WG III Chapter 1:
R. Squitieri
J. Stiglitz

FROM: Susan Henson

SUBJECT: Late Reviewer Comments on Chapter 1

DATE: April 18, 1995

This fax consists of 3 page(s)

MESSAGE:

The attached comments were inadvertently omitted from the U.S. review process. If it is not too late, please consider them.

Thank you.

Susan Henson

04/18/95 07:38

202 554 8713

USGCRP OFFICE

STIGLITZ

002/003

04-04-1995 11:47AM

FROM OCS/ECONOMICS GROUP

TO

92025546715

P.02

Chapter
1U.S. Dept. of Commerce
Bureau of Economic
Affairs

Comments on IPCC Working Group III (Economics) Assessment

The following are my comments on pages 1-2, 31-32, and 51-52 of the draft IPCC Working Group III Second Assessment Report. The comments are noted on the attached draft itself. Additionally, to ensure legibility, the comments are listed below according to page and line number. (My explanatory comments are in italics.)

<u>Page Number</u>	<u>Line Number</u>	<u>Comment</u>
1	29	Change "will" to "will"
2	14	Change "reducing" to "increasing" ?
32	2	Change "coal" to "proved" [There seems to be confusion both here and in note number 84: It is not known whether all coal stocks have yet been discovered. It seems the discussion means to refer to "proved" or "unproved" reserves - which exist both for coal and for oil and minerals. The satellite accounts released by Department of Commerce found that additions are still being made to proved reserves of all minerals, including coal.]
32	3	Change "oil or minerals" to "possible," "probable," or "undiscovered" reserves
32	6-7	Change "Four" to "Various" and delete "(Peskin and Lutz)" [Much work has been done since the Peskin and Lutz discussion.]
32	9	Delete "used recently in the United States," [The U.S. compiles pollution abatement expenditure data but does not use it to adjust GDP. Also, this is an outdated reference; the U.S. has done work since, see edit for item d)]

32 new lines

Insert A: Change item d) to: "More recently, the revised System of National Accounts 1993 (SNA) and the U.N. Handbook on Integrated Environmental and Economic Accounting (SEEA) recommend the use of satellite accounts to account for the interaction of the economy and the environment. The United States Department of Commerce recently released a satellite accounts framework and initial estimates for mineral resources. These estimates focused on market prices, in keeping with the national accounts' intent to measure production, rather than to produce an indicator of welfare."

32 19 Change "broad-based" to "the natural environment--that is a more broadly-based welfare measure--"

52 16 Delete sentence beginning "The reason is simply..." [This statement is incorrect. GDP, by definition, does not deduct depreciation. The definition of net domestic product is gross domestic product less depreciation.]

52 18 Change "the change in capital stock" to "-the decline in the value of the capital stock before investment is taken into account." [The definition, as written, is incorrect.]

52 25 Change "coal" to "proved" [As discussed above.]

52 26-28 Delete sentence beginning "Costs of extraction..." [As discussed above.]

52 28 Change "oil and other minerals" to "unproved reserves" [As discussed above.]

52 36-37 Delete the sentence beginning "This accounting framework..." [Use of zero rents is necessary only if there is no technology or technical change; otherwise, the accounting framework can be used without assuming infinite reserves.]

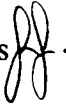


INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

145 King Street West, Suite 1002, Toronto, Ontario M5H 3X6 CANADA
Tel: (416) 369-0900 Fax: (416) 369-0922

MEMORANDUM

TO: Dr. William Cline
Dr. Joseph Stiglitz
Prof. Ken Arrow
Dr. Mohan Munasinghe
Prof. Karl Goran-Maler

FROM: Dr. Erik Haites 

RE: Comments on Chapter 4

DATE: March 24, 1995

Here is a complete set of comments on Chapter 4 for your review. We have also enclosed a diskette copy in WordPerfect 5.1 of this.

We would like to have another draft of your chapter for review by the Bureau by April 24. If possible, please provide an electronic copy (WordPerfect 5.1) of the revised chapter.

Chapter Four

WORLD Governments/Organizations Review of the Second Assessment Report

Chapter 4: INTERTEMPORAL EQUITY AND DISCOUNTING

4.0	General Comments and <i>Summary</i>	<i>ii-iii</i>
4.1	Introduction	1-3
4.2	Intergenerational Equity	3-5
4.3	Discounting and the Social Rate of Time Preference	5-14
4.4	Formulation of Descriptive Approach	14-17
4.5	Discounting for Risk	17
4.6	Producer or Consumer Interest Rates?	17-19
4.7	Discounting Environmental Impacts	19-20
4.8	Implications for Sustainable Development	20-22
4.9.1	<i>Annex 4A</i>	23-26
4.9.2	<i>Endnotes</i>	27
4.9.3	<i>References</i>	28-33

Reference			Comments	Reviewer (Country #)	ID	Response	
Section	Page	Line					
04 Intertemporal Equity and Discounting							
0	0	0	This is a clearly written and rigorous exposition of discounting and inter-temporal equity. Is this topic, covered in 32 pages including references, of sufficient interest to policy makers and government delegations to form part of the main SAR? As a paper in a separate volume of Technical Papers it would have greater merit (some material in a few other chapters could be similarly handled). This material is familiar enough to those who follow the relevant academic literature, but there is widespread feeling that economists in this area wax over-long and over-enthusiastically on discounting and discount rates. The essence of the topic could be adequately covered in 2 or 3 pages and go into a slightly expanded section in Chapter 5 (pp. 32-33) or Chapter 6 (section 6.1.5 at p. 7). This proposal should not be viewed as a negative comment, but a reflection of the subject matter and its prioritisation for most potential readers. A box might have been prepared which summarised why some people are deeply opposed to the application of discounting (or maximisation of net present value) to intergenerational and other sustainable development issues.	WEC	01	A	
0	0	0	It seems that the scientific information and the more personal views of the authors are not clearly separated. There is an obvious lack of coordination between chapters three and four. The key message seems to be that there are several arguments for choosing a high discount rate or a low one; the final choice is really up to the policy-makers. More attention could be paid to the (especially moral) implications of using a discount rate. The differences between prescriptive and descriptive need to be clearly stated.	NED	09	G	
0	0	0	Re. page iii, line 12. What is the scientific basis for these numbers? Suggest deletion.	NED	09	G	

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
0	0	0	General Comments	SWED	17	G	
			1) with strong arguments against using a non-zero pure rate of time preference can not see why a zero or at least a very low rate is not recommended in the text. 2) Discounting due to an expected increase in per capita income in the world is discussed and it is recognized that the relative per capita growth need not be constant over time. If it declines over time it implies that also the discount rate should decline. In combination with a low or zero rate of time preference, this has considerable implications for how impacts occurring far into the future are valued. This should have been illustrated in a diagram as well as mathematically. (See attachment)				
0	0	0	While it is true that "identifying the proper discount rate is probably the single most important analytical step in the economic analysis of climate change", the cited sentence might create the impression that one can analytically derive a value for the discount rate. This is impossible because one component of the discount rate must be determined by the pure time preference, must be determined by ethical considerations. Thus it should be stressed that (i) the discount rate is to a decisive extent determined by ethical considerations and (ii) the choice of crucial importance for the cost analysis of climate change.	SWED	17	G	
0	0	0	Can this issue meaningfully be expressed as a discounting problem? Much of the benefit that will take place far in the future cannot reasonably be estimated, it involves health and ecosystem effects which are ill-defined and whose valuation is uncertain and controversial. This suggests that a multi-criteria approach to the problem is more suitable. Suggest organizing the chapter along the following lines: - Economics provides no clear answers to many of the issues raised by discounting in this situation. There are strongly held views on all sides of the question. - The use of MCA provides an alternative to trying to discount the future benefits of current climate change mitigation strategies, although MCA is not without its own drawbacks. - There is a strong philosophical following for the use of low social discount rates for discounting future consumption, and a strong practical following for the use of rates nearer market levels.	IPIECA	18	A	

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			Trying to value the effects of foregone investment on future consumption is complex and possibly subject to manipulation. It is hard to justify lower discount rates for this particular type of social investment than for the many other types of investment that are currently made. Faced with this dilemma, some analysts have chosen compromise rates between these positions. An alternative is the use of multiple discount rates by analysts. The implications of this approach, with all results provided to other analysts and policymakers, might usefully be addressed in this chapter.			
0	0	0	Re. p. ii, lines 3-7. The recognition that this is a philosophical and ethical question as well as an economic one is important. However, this also means that there can be no one right answer to the discount rate question. To communicate to policymakers the necessary absence of a "proper answer" to this question is important in an assessment of economic knowledge to the climate change question. Re. p. ii, lines 31-32. Consistent with the comments on lines 3-7 by this reviewer, avoid implications of there being a proper answer. Re. p. iii, lines 30-32. The authors should be complemented for their efforts to include views of the discount rate, such as those held by Schelling and Nordhaus, which are different than their own. However this summary gives short shrift to the "descriptive" approach. The implication of a trust fund earmarked for greenhouse victims seems extreme. The summary lacks discussion on sections 4.5 to 4.8.	IPIECA	18	A
0	0	0	Overall this chapter is comprehensive, balanced and reasonably well written survey and evaluation of the available literature. Moreover, the chapter summary was in general a fair representation of the body of the text and was, in turn represented effectively in the PMS. Each of these aspects of the text should therefore be supported against any attempts to substantially amend them. The chapter summary and more importantly, the policymakers summary, does not adequately represent the treatment in the text of the alternative approaches to discounting, on the one hand, and the (affordable) safe minimum standards/natural capital approach on the other. This could be done and injected into the chapter on discount rates.	AUST	23	G
0	0	0	There is a danger in assessing the impacts of climate change that assessors will consider the issue as but one other "project" and rely on existing literature about	CAN	24	G

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			discount rates and their optimal levels. The problem of climate change is a very long-term "project" and as stated in this chapter discounting is one of the critical issues in assessing its costs.				
0	0	0	This chapter seems rather esoteric and much of it is unintelligible.	CAN	24	G	
0	0	0	Re. p. ii, lines 32-34. The intergenerational equity questions are profound. GHG stabilization objectives may require substantial abatement by some of the world's poorest countries. Some of the benefit of these abatements will accrue to the wealthy. Vulnerability to climate change may be the greatest in the poorer countries. Questions about how to share the costs of abatement and distribute climate change damages are no easier to resolve than those regarding intertemporal questions. This should be handled by a clearer sense of the relationship between chapters 3 and 4.	USA	32	G	
0	0	0	Re. p. iii, lines 28-32. The authors argue that the proceeds of market investments are not likely to be set aside to compensate those adversely affected by climate change. The implication is that market rates of interest, or opportunity cost of capital, are inappropriate for discounting future benefits of climate investments. The argument is not convincing. While investment proceeds are unlikely to be set aside directly for the exclusive use of climate change victims, market investments will benefit individuals in the future, even the distant future. The opportunity cost of climate investments include foregone investments that would augment human and physical capital. Augmentations to the stock of human and physical capital will expand capacity to produce consumption goods in the future, thereby benefiting future generations. In fact, the industrial age has witnessed an extraordinary increase in wealth and living standards as one generation inherits capital from the previous generatin and leaves a larger stock of capital to the next generation. Also note that, although little physical capital from the dawn of the industrial age has survived to the present, no one can doubt that investments made at that time yielded benefits that still enrich us today, two centuries later. These benefits accrue to us today even though no one thought to earmark and reserve them for the end of the 20th century. Given the history of the creation of wealth over the past 200yrs, it is puzzling that the authors dismiss the possibility of adding to the wealth of future generations through investment in any projects but those that mitigate climate change. If this hypothesized inability to benefit the future by current investment is the sole argument against use of the opportunity cost of capital as the discount rate, then this criticism does not seem to	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			be fatal. Use of the opportunity cost of capital as the discount rate would seem to be a defensible position. The chapter, which gives far too little attention to the opportunity cost of capital approach should be revised to correct this deficiency. However, we should be careful when thinking about our assumptions regarding the motives of past generations and their sense of moral obligation to us.				
0	0	0	Re. p. iii, lines 30-32. The authors should be complemented for their effort to include views of the discount rate, such as those held by Schelling and Nordhaus, which are different than their own. However, this summary gives rather short shrift to the "descriptive" approach. In particular, the implication that society needs to set funds aside, as in a trust fund, earmarked for eventual compensation of greenhouse victims seems extreme. So long as funds are invested productively, they will be available to future generations. Incremental economic growth provides the resources for future compensation for future victims. Compensation is really a redistribution problem for future generations, which can not and should not be solved now.	USA	32	G	
0	0	0	Page ii Summary, Lines 3-7 The recognition that this is a philosophical and ethical question as well as an economic one is appropriate and important. However, this also means that there is a range of advice based on different prescriptive and descriptive considerations. To communicate to policy makers the necessary absence of a definitive answer to this question is important in assessment of economic knowledge as applied to the climate change question.	USA	32	G	
0	0	0	Page ii line 20 How accepted is the Brown-Weiss argument? My sense is that it is not supported by any treaty. Rather it is more an ethical norm. Does terming it an international legal principle give it more weight than other philosophical criteria (eg. Rawls' difference principle or Nozicks theory of rights)?	USA	32	G	
0	0	0	COLLATED COMMENTS IPCC WORKING GROUP II DRAFT ASSESSMENT Chapter 4: Intertemporal Equity and Discounting Lead Reviewer's Overall Summary and Comments for Review Process:	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			The chapter lays out the central issues of the longstanding discounting debate in economics somewhat independently from the specific program of global climatic changes (GCC). What connections there are to GCC are made strictly from the view of largely deductive economic theories. The chapter attempts to distinguish a "prescriptive" and "descriptive" as a way of introducing a more inductive approach but then seems to reject this view on "ethical" reasons. This is somewhat surprising, since the ethical arguments mentioned are more a matter of practicalities (ensuring future transfers) than they are a genuine consideration of moral obligations (e.g., stewardship). Of central concern is whether or not the chapter conveys to policy makers what they need to know to make informed choices regarding the discount rate for policy analysis in GCC. I think there are several serious problems here: I. The chapter fails to consider the more fundamental issue of the nature of the problem. As one reviewer points out, the authors proceed as if all the consequences can be framed as a gradual process of incremental damage. Under these conditions, the problem collapses to a debate over rates that may be of great interest to economists, but I believe will be regarded by policy makers as missing the point. In contrast, another reviewer faults the chapter for treating GCC as a special case. While I am inclined to believe it is, for a number of natural and social scientific reasons, I agree that the authors have not made the case here. The chapter should begin with a clear essay on why GCC is or is not different from any other policy concern. For example, the chapter states that future generations can be compensated for "some" environmental/natural resource effects, but what about the "and not for others" case? This should be followed by a discussion of the significant views of "better off" that would be at the core of alternative normative perspectives for this problem if we were to treat it as a special case. The relationships between Chapter 3 and this chapter should be clarified. II. The economic perspective should receive special attention, but the authors should carefully delineate normative and positive results. Policy makers will want to know when prescriptions are based on normative models (some of questionable empirical validity), and when they are based on credible scientific evidence. The chapter's distinction between "prescriptive" and "descriptive" approaches is misleading. In fact, both approaches are prescriptive; however, one is based on a largely deductive methodology while the other is more inductive. Both approaches are often at odds with empirical results in decision making and market behavior in the case of unfamiliar or poorly defined goods (and these major results should be made clear for policy				

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			makers). What the authors present as an "emerging consensus" regarding discounting is clearly not one, given the reactions of the reviewers. III. Very little discussion is devoted to the implications for policy analysis in the real world. As examples, the chapter does not offer insights for sensitivity analysis, scenario development, or alternative treatments of the problem as might follow from specific stabilization policies. Contrary to the tone in the SUMMARY which endorses cost-effectiveness analysis (but not cost-benefit analysis) and a variety of ethical principles for addressing equity, the tone in this chapter emphasizes finding the "correct" rate of discount to decide about alternative policies. The chapter seems determined to make a single recommendation, rather than explicating reasonable alternatives that reflect different normative commitments and preferences. In addition, the chapter should more carefully distinguish the interesting cases of this problem: policy choice, project choice given a policy goal, catastrophic risks, and cooperative and non-cooperative policy strategies. IV. Key concepts and examples need clarification and editing. Some examples are confusing, key concepts are introduced with little definition, abstract methodological concerns are raised but not explained, and, as currently written, the annex does little to resolve concerns about the normative perspective or its empirical grounding. To help the authors think about revisions, I have organized all of the general comments under the four categories discussed above. In some cases, I have appended to a comment from a reviewer some additional concerns of my own. The specific comments are ordered by page and line number, but the category concerns are noted there as well. General Comments on Chapter from Reviewers: I. Intertemporal Equity 1. The Inappropriateness of Discounting A. Assuring Climate Change. Since the costs of averting change occur in the present, and the benefits in the perhaps distant future, discounting dramatically devalues the future values associated with it. Ironically, if we assume a smooth warming path with slowly accumulating net damage (as these authors do for the most part) then the adoption of this framework alone constitutes the decision to do nothing. There is no need for any analysis within it. This assures that the goal stated in the "Summary for			

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			Policy Makers" of "stabilization of greenhouse gas concentrations" will never be met. The conclusion is such a short inference away from, and so completely determined by, the (unjustified) assumptions of the method that the whole thing seems silly. B. Immortal Agents. The authors are quite mistaken to brush aside Tom Schelling's criticism that long term discounting assumes an immortal agent. Surely Schelling is right that there is a world of difference in thinking about my own future consumption and that of others. This difference causes the whole framework used by this chapter to collapse. The authors have conflated issues of allocation with those of distribution. This is completely illegitimate. C. Time and its Correlates. Further still, the idea of discounting is far more problematical than normally assumed by these authors. As Derek Parfit has argued, discounting typically confuses things that are correlated with time, with time itself. A variety of arguments are offered in support of discounting: risk, opportunity costs, the supposition that future generations will be better off than we are, etc. But in none of these cases, is it time itself that is the key issue. These authors exhibit these confusions in numerous places including pages 9,11 and 17. D. Time Preference. We would think much more clearly about the future if we used a disaggregated vocabulary rather than starting with the assumption the there is a social discount rate. I think that there are also reasons to doubt that individuals have a rate of time preference; or at least, that it functions in the broad way that economists assume. For example, why must present and future time value be related by an exponential function? Why not some other relationship? What is referred to as time preference needs to be disaggregated in much the same way as "the" social discount rate. See, for example, Rawls' discussion of this subject in A Theory of Justice. 2. Problems with the Point of Departure A. Distributing Utility. The authors are quite mistaken in thinking that the issue is the distribution of utility. Utilitarianism has been virtually universally rejected by philosophers, but the authors seem unaware of this literature. Their statement (page four) that their approach derives from a "persuasive axiomatic structure" hovers somewhere between irrelevant and outrageous. They seem uninterested in the questions of whether the system is true or not. Who cares if it is axiomatic or not. The utilitarian project has failed utterly to offer a satisfactory account of moral obligation.				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			- Utilitarians have been unable to show how to get from the (I believe false) proposition that everyone seeks to maximize their own utility, to the idea that we have a moral duty to maximize the utility of everyone. - In offering no place for the language of rights (Bentham referred to rights as "nonsense, nonsense on stilts") it authorizes the ruthless exploitation of the minority if we can show a net gain of utility. - It is infeasible from a motivational point of view in the classical version (greatest happiness of the greatest number) because it requires more altruism than we can reasonably expect people to muster. (Further, it is mathematically impossible to maximize two variables.) The self-interested motivational assumption of the neoclassical school fails for the opposite reason in that it fails to offer any account whatsoever of what we owe one another. The attempts on the part of modern economics to distance itself from the failure by dropping the language of utility in favor of that of preferences backfires. If preferences are not connected to utility then it is completely mysterious why one should care about them. Incidentally, a utilitarian should consider the preferences of at least some nonhuman animals since many of them can also experience pleasure and pain. B. Finding a Foundation. Not all goods are, or should be, tradable at the margin. Coase type transactions cannot go all the way down--otherwise we would have to bribe people not to assault us. The way all societies actually function is to block a set of exchanges and then allow Pareto transfers above those constraints. In our society, for example, votes cannot be legally marketed, nor can certain fiduciary goods like national battlefields. C/B analysis sheds no light on which exchanges should be blocked. One might reasonably assume that exchanges that impair the earth's life support systems should be blocked as we have done in the case of ozone depleting chemicals. 3. An alternative point of departure: Trusteeship The authors seem to misunderstand the trust model (p. 3) in that they imply that it allows for perfect substitution. Here they conflate technical with moral substitutability. The conventional efficiency/equity distinction is dysfunctional because it misunderstands the nature of goods. A. Problems with the Efficiency/Equity Distinction. In the standard view there are two				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			objectives for policy: efficiency, to be achieved by corrected markets; and equity which is usually not very robust- but is either a constraint on efficiency or is some ways to be traded off against it. There are a number of problems which go way beyond the one normally recognized: that economics doesn't have much to say about equity. First, the basic distinction does not parse at the joints. The idea is that there are goods traded in corrected markets that yield efficiency makes it sound as if there is only one or two kinds of goods. But Walzer is certainly correct in Spheres of Justice in his observation that goods move in accordance with their meanings as much as with their prices. There are at least four different classes of goods in all societies: 1) those traded in markets; 2)those distributed according to merit--public office, licenses to practice medicine and the like; 3) those distributed according to need--e.g. food stamps; and 4) fiduciary goods which one generation preserves for those who follow. (My argument is that because of its role in the preservation of species and cultures that climate is a good of this kind.) Seen from this perspective the role of public policy is the proper maintenance of these various spheres--not the maximization of utility or consumption in one of them--the market. Market Preconditions. Once we distinguish between markets and their preconditions the question arises of how should we think about those preconditions. In Restoring the Public Trust I argue that a fiduciary model captures what is at stake with respect to climate change. This grounds, I believe, an obligation to leave the world at least as good as we found it--meaning leaving its productivity and diversity intact. Because of the role of climate change in species extinction, and as a possible threat to some of world agriculture, I argue that there is an obligation to stabilize climate. Seen from this point of view the role of economic analysis is to be concerned with discovering the most cost effective means of reaching the goal of having GHG emissions and sinks in rough equilibrium. A. Tractable Morality. There is no obligation to maximize utility or preference satisfaction or anything in that family of ideas. We have a much more tractable account of our moral obligations. Rather, we can follow Locke in stating our obligations in terms of the preservation of persons: understanding this to mean preserving their lives from external threats, preserving and enhancing their moral and religious choices, and assuring the means to subsistence. In the trustee conception the fundamental job of the nation states is not to create opulence or to correct for market failures--but to preserve the persons of their citizens				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			now and in the future. An element in this overall obligation is to keep the various kinds of goods discussed above in proper balance. Other Problems. This chapter also fails to draw on the large literature on intergenerational justice. An excellent compendium by Bayard Catron entitled Ethical Dimensions of Environmental Policy and Decision Making: Risk Management, Intergenerational Equity, and Discounting(Washington, D.C.: NAPA, 1993) would have helped a lot. Beyond this the authors seems unaware of the literature on the nature and unpredictability of ecological change. See, for instance, C.S. Hollings, "A Cross-Scale Morphology, Geometry, and Dynamics of Ecosystems in Ecological Monographs 62(4) 1992, pp. 447-502, esp. pp. 478-485 for a discussion of the inherent unpredictability of the future. 4. Social welfare functions are generally assumed to be an summary of the preferences revealed by a political process, and are used as a convenience in theoretical explorations of the necessary conditions for maximizing some concept of social welfare in which both efficiency and equity matter. When a policy that satisfies the efficiency conditions results in a redistribution of income that is judged to be undesirable (based on some idea of a social welfare function) the consensus approach is to design compensatory programs or transfers that make it possible to achieve both efficiency and equity. This is the Birdsall and Steer recommendation. The "prescriptive" approach abandons any efforts to reconcile efficiency and equity, and recommends policies that leave all generations worse off compared to the welfare they could achieve if efficient climate policies were adopted and intergenerational transfers dealt with through policies affecting savings and investment. Birdsall, N. and Steer, A. Act Now on Global Warming - But Don't Cook the Books, Finance and Development 30 (1), pp. 6-8. 5. The discussion of the chapter on the problem of earmarking revenues for future generations in a Fund for Greenhouse Victims (Page 16, lines 33-35) is both erroneous and irrelevant if the possibility of providing for future generations through capital investment is admitted (Stiglitz). Today's investment in physical capital increases future productive capacity; no other funding is required to make future generations better off. Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982.				

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			6. I have a serious interest in this issue, and found Chapter 4 to be helpful to my own thinking. However, I feel the chapter overstates the merits of the prescriptive approach relative to the merits of the descriptive approach. My comments below elaborate on this point, and suggest some textual changes that would help to redress the balance. The primary criticism leveled at the descriptive approach is that there is no guarantee that investments we make now will ultimately benefit individuals in future generations who may be harmed by climate change. However, this exaggerates the difficulties of transferring non-environmental capital to those harmed by climate change, and it fails to recognize the difficulties inherent in transferring environmental capital. Barring an event like the "dark ages," investments which expand the stock of technological knowledge cannot easily be squandered by future generations. Moreover, since the benefits of advancing technology are significantly a public good, it is not plausible that these benefits will somehow fail to help the particular individuals in future generations who may be most harmed by climate change. Likewise, investments in education, particularly of women, seem to produce self-sustaining social change which lowers population pressure, and this too has spillover benefits to all members of future generations. Thus some very important classes of non-environmental investments are likely to have enduring payoffs in future generations, and those payoffs are likely to be available to those who are ultimately harmed by climate change. Moreover, it should be acknowledged that environmental investments we make to reduce CO2 emissions can be subverted in the future, as long as oil, gas, and coal resources remain available to be used at some future date. Thus today's investment in CO2 emissions reduction may be equally or more at risk of being squandered or "misappropriated" than investment in other kinds of non-environmental capital, particularly education and research. 7. As Chapter 4 acknowledges, the prescriptive approach is fundamentally an ethical position, shared (more or less) by many social scientists who are highly educated and wealthy, at least relative to the people likely to bear the cost of controlling CO2. If the observed income redistribution policies of the world's governments are grossly inconsistent with the ethical norms of these individuals, it seems to me that the common sense explanation is that most of humanity does not share these ethical norms. The chapter acknowledges that this is possible, but the point is "soft-pedaled," particularly in the summary section where it is not mentioned (even though the critique of the descriptive approach is prominently featured there.)			

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			According to Aaron et al. (1994), these values are affected by affluence. Our future generations, if wealthier and better educated, can be expected to place more value on "respecting and preserving nature and the natural." Will this be handled in the estimates of avoided damages? Aaron, H.J., Mann, T.E., and Taylor, T (eds), 1994, Values and Public Policy, The Brookings Institution. 8. It seems to me much more work needs to be done on telling the modelers how to design their models so as to answer the questions that are imbedded in the discount rate issue. To the extent that the present is transferring substantial resources to the future, we ought to be able to tell people how much. To the extent that under reasonable assumptions per capita consumption will be greater in the future, again, we should know much greater. In other words we shouldn't bury major ethical decisions in the discount rate. In part, this is a result of the lack of connection between Chapter 3 and 4. If the authors want to set aside the major ethical issues then they should explain how decision rules from Chapter 3 will interact with the approaches in Chapter 4. 9. One reason for this is that the preferences of today as expressed by democratic governments, as Chapter 4 notes, differs drastically from the consensus of economists as moral philosophers. We need to give the democratically elected decision makers the information needed to make these decisions, not bury the decision in the choice of a discount rate which reflects our moral judgments which are not those of the public. If we don't do this, our work will become more and more irrelevant. II. Economic Efficiency and Discounting 1. The chapter is unbalanced in its presentation of the economic theory relevant to choice of discount rates. It is not the consensus of professional economists that the social discount rate should be based on the kind of ethical judgments used in the "prescriptive approach" to justify a discount rate of 3% or less. What the chapter labels the "descriptive approach" is in fact the mainstream approach to the subject. The chapter should concentrate on the descriptive approach, and give the prescriptive approach only brief mention as a perspective that suggests climate policy should be treated as a special case and based on ethical judgments that have not been embodied in any other economic policy.				

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			2. The chapter fails to provide a justification for choice of a discount rate lower than the before tax return to capital. What Stiglitz, Dreze and Sandmo, Arrow and Kurz and others demonstrate is that when governments cannot use either optimal taxes or make lump-sum intergenerational transfers, the correct discount rate for evaluating public investments may not equal the before-tax return to capital. There are necessary conditions for welfare maximization that must hold among the return to capital, before and after tax rates of return, and the social discount rate. The chapter states correctly (Page 13, Line 2) that with nondistorting taxes and optimal intergenerational transfers, the social discount rate will equal the before tax return to capital. The chapter is incorrect in dismissing this as a special case. These assumptions are the normal starting point for applied welfare economics. The burden of proof should be on those who argue for different assumptions. Moreover, as will be discussed below, alternative assumptions do not lead to any simple characterization of the social discount rate. 3. If existing taxes create significant distortions between the before and after tax returns to investment, a case can be made for choosing a discount rate between the two (as Nordhaus and others suggest) or for converting foregone investment to consumption at the before-tax return to capital. These are necessary conditions for intertemporal efficiency, and hold regardless of the choice of a social welfare function. Choosing the weights to be applied to before- and after-tax rates of return in computing the average requires an explicit analysis of how climate policy affects investment and consumption. The chapter includes no such analysis and therefore has no basis for concluding that the correct discount rate is not the before tax return to capital, as it would be if the costs of climate policy all come from investment. Nordhaus, W. D. Managing the Global Commons: the Economics of Climate Change. MIT Press, 1994. 4. It is only if governments cannot make intergenerational transfers that choosing a social discount rate different from some weighted average of before and after tax rates of return to capital can be desirable (Stiglitz). But this does not justify an analysis that constructs a social rate of discount from ethical principles, as the prescriptive approach recommends. Instead, the correct theoretical approach (Stiglitz, Arrow and Kurz) is to model explicitly the constraints presumed to exist on intergenerational transfers, the characteristics of the investment in question, and the relation between climate policy, consumption and investment. As Stiglitz shows, the conclusions that follow about the relation between the social rate of discount and returns to capital (before or after tax) will depend on all these factors, and the social rate of discount may be higher or lower than the before tax return to capital. The conclusions that the chapter reaches on the				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			range of discount rates is not based on any such analysis, and therefore has no foundation. Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982. Arrow, K. J. and M. Kurz. Public Investment, the Rate of Return and Optimum Fiscal Policy. Johns Hopkins University Press, 1970. 5. All of the theory of social discount rates assumes that governments attempt to maximize a social welfare function, but face constraints on tax and transfer policy that make it necessary to choose a social discount rate different from the private return to capital. None of the economic theory of discount rates is based on the assumption that governments are maximizing the wrong social welfare function. This is the assumption on which the prescriptive approach adopts (Page 12, line 32). The prescriptive approach posits a social welfare function different from that which governments are assumed to be maximizing in making economic policy, and then uses it to argue for a low discount rate for climate policies. That entire line of reasoning is illegitimate, and certainly does not represent the consensus view of mainstream economists. 6. The "descriptive" approach, which assumes that the preferences revealed by current policies reflect the social welfare function of the nation in question, is the mainstream approach and should be presented as such. The complexities involved in choosing a discount rate for public investment with constraints on tax policy and distribution can then be discussed in that context. 7. The prescriptive approach is relatively well-explained. However, the descriptive view is not presented very coherently. It points to the relevance of alternative investment opportunities, but does not specify exactly what the discount rate should be. 8. The main area of omission in this chapter is the psychological work on intertemporal choice. This research shows a number of decision biases that may have policy implications. Below is a reference list of some potentially relevant papers. Benzion, U., Rapoport, A., and Yagil, J. (1989). Discount rates inferred from decisions: An experimental study. Management Science, 35, 270-284. Cairns, J.A. (1992). Health, wealth and time preference. Project Appraisal, 7, 31-40. Cropper, M.L., Ayded, S.K., Portney, P.R. (1994). Preferences for life saving				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			programs: How the public discounts time and age. <i>Journal of Risk and Uncertainty</i>, 8, 243-265. Ganiats, T.G. (1994). Discounting in cost-effectiveness research. <i>Medical Decision Making</i>, 14, 298-300. Keeler, E.G. & Cretin, S. (1983). Discounting of life-saving and other non-monetary effects. <i>Management Science</i>, 29, 300-306. Lipscomb, J. (1989). Time preferences for health in cost-effectiveness analysis. <i>Medical Care</i>, 27, s233-s253. Loewenstein, G. (1987). Anticipation and the valuation of delayed consumption. <i>Economic Journal</i>, 97, 666-684. Loewenstein, G. (1988). Frames of mind in intertemporal choice. <i>Management Science</i>, 34, 200-214. Loewenstein, G. & Prelec, D. (1992). Anomalies in intertemporal choice: Evidence and interpretation. <i>Quarterly Journal of Economics</i>, 107, 573-597. Loewenstein, G. & Thaler, R.H. (1989). Anomalies: Intertemporal choice. <i>Journal of Economic Perspectives</i>, 3, 181-193. Olsen, J.A. (1993). On what basis should health be discounted? <i>Journal of Health Economics</i>, 12, 39-53. Prelec, D. & Loewenstein, G. (1991). Decision making over time and under uncertainty: A common approach. <i>Management Science</i>, 37, 770-786. Redelmeier, D.A. & Heller, D.N. (1993). Time preferences in medical decision making and cost-effectiveness analysis. <i>Medical Decision Making</i>, 13, 212-217. Redelmeier, D.A., Heller, D.N., & Weinstein, M.C. (1994). Time preference in medical economics: Science or religion? <i>Medical Decision Making</i>, 14, 301-303. Shelley, M.K. (1993). Outcome signs, question frames, and discount rates. <i>Management Science</i>, 39, 806-815. Shelley, M.K. (1994). Gain/loss asymmetry in risky intertemporal choice. <i>Organizational Behavior and Human Decision Processes</i>, 59, 124-159. Thaler, R.H. (1981). Some empirical evidence on dynamic inconsistency. <i>Economic Letters</i>, 8, 201-207. An important issue to resolve for policy makers: How is it we can seriously challenge decision making for unfamiliar goods and not "choices?" In addition, what do these studies indicate about framing the "time horizon?" 9. This seems to me to be the next step in the process of creating the models and analysis that will help us perform a systematic economic analysis of climate change policies. 10. The chapter exhibits two strong biases of the authors: (1) the "proper" discount				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			rate is the social rate of time preference (SRTP) and (2) the component of the SRTP corresponding to the pure rate of time preference should be set equal to zero. These positions do not represent the consensus of the economics profession and the chapter should be revised to provide greater balance in the treatment of different approaches to discounting. 11. The formulation of the SRTP as the sum of the pure rate of time preference and an adjustment for changes in the marginal utility of consumption due to per capita consumption growth is presented as if this is a general result that is value free. It is described as "the fundamental equation for the discount rate of consumption," (page 6, line 44). This treatment obscures normative assumptions that underlie the derivation of the SRTP. For example, the derivation is dependent upon acceptance of assumptions about "welfarism," (the concept that social welfare is a function of only the welfare of individuals), the comparability of welfare across individuals, and a specific class of social welfare functions. The underlying social welfare function assumes that social welfare in time t is reducible to per capita consumption in time t and is independent of the distribution of consumption among individuals in time t. Individuals living in different periods enter the social welfare function identically with the exception of a discount factor for pure time preference that varies as a function of distance from the present. These normative assumptions yield a SRTP that varies with per capita consumption growth, adjusted by the marginal utility of consumption, but not, for example, changes in the variation of consumption across individuals. The assumptions may be reasonable approaches to simplifying the problem intertemporal optimization and discussion of them may not be necessary when writing for professional economists. But the audience of the WGIII report will include non-economists. For these readers, it is important to make the normative underpinnings of the SRTP explicit and discuss what they imply about intergenerational and intragenerational equity. 12. This chapter has improved over earlier versions, but still could use some work. One general suggestion would be to have the chapter consider efficiency on a level more comparable to the current emphasis on equity. For example, shouldn't efficiency be in the chapter title and receive more attention in the summary? Also, there could be some additional explicit discussion of what efficiency means in the intergenerational context; the standard view that efficiency is a less controversial criterion than equity				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)	#		
			has some merit for this application. III. Implications for Policy Analysis 1. I believe that the Chapter is an excellent survey of the issues and literature on discounting and intergenerational equity. It falls short of giving the modelers who are trying to evaluate alternative policies any specific guidance. I suggest an approach to this shortcoming. I also feel too little has been said about sequential analysis of options and particularly the option of waiting. 2. However, if I were one of the two or three dozen researchers developing integrated assessment models, I probably would feel let down that I wasn't told which rate I should use in my model, or more importantly, how I might modify my model or use it to answer the questions regarding efficiency and intergenerational equity that are addressed in Chapter 4. 3. Let me suggest an approach, although time and space preclude a complete analysis of this issue which should be the next project for research on discounting and global climate change. I believe the key to the answer lies on the discussion on pp. 13-14. There are two key rates: (1) the rate at which we discount consumption and (2) the marginal rate of return on investments that are alternatives to investments in climate change abatement. I suggest that we keep these two rates separate in our models for the purpose of clarity. For example, in integrated models that explicitly model economic growth, one would use the rate of return on alternative investment in determining the growth path and consumption path if the proposed investment in climate change were instead invested in the economy. Consumption over time would then be discounted to its present value using a rate reflecting the SRTP. This would then become the baseline against which global climate policies would be compared. This seems to be what the chapter is suggesting, but it is somewhat hidden by all the other arguments. 4. This approach is very similar to the shadow price of capital approach, however, by disaggregating the analysis, it forces us to specify and debate what the alternatives to investment in climate control are and what rates of return could be earned. It forces us to look at consumption rather than GNP. We can debate and vary the SRTP of discount separately. In short, it helps us keep straight the myriad of issues that are involved and doesn't bury them in a single discount rate. For example, Cline gets a discount rate of 2% - 3% (p. 14) by assuming that 80% of				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			cost comes at the expense of consumption and 20% at the expense of investment. Such an assumption might have followed from the assumption that the money was raised by taxation and the marginal propensity to consume was .8. The problem with this analysis is that the government could have invested it in other public projects. The problem with most second-best lines of analysis is that we don't properly account for the opportunity cost and the approach suggested above would force us to do that. 5. Finally, we need to look more carefully at sequential approaches to this problem. The sequence we should follow is not necessarily act, learn, act. The optimal sequence, given the uncertainty we act may be to wait, learn, wait, learn, maybe act. Given the feasible size of budgets that will be devoted to this problem, gathering information and developing the technologies for the future may be our best option. 6. Economists know something about how individuals and companies trade off current and future cash or consumption. We know much less about how people trade off their consumption for the consumption of their descendants -- or don't like the answer we observe in such behaviors as national finances. We have even less to say about how people trade off their consumption relative to the consumption of future generations in other countries -- or don't like the answer at all, as demonstrated by the abhorrence of the American electorate for foreign aid. Can this meaningfully be expressed as a discounting problem at all? Schelling's argument that after a certain point future generations run together has some real common sense to it. Furthermore, much of the benefit that takes place far in the future cannot reasonably be estimated anyway, because it involves health and eco-system effects which are not well-defined and whose valuation is uncertain and controversial. This suggests that a multi-criteria approach to the problem is more suitable. However, this risks painting the problem as one of fundamental values of current generations about their stewardship responsibility over the planet and its future inhabitants, and thus losing the sense that these are small benefits far in the future. 7. These are topics of greater than average difficulty. Consideration should be given to organizing the chapter along the following lines: - Economics provides no clear answers to many of the issues raised by discounting in this situation. There are strongly held opinions on all sides of the question. - The use of multi-criteria analysis provides an alternative to trying to discount the future benefits of current climate change mitigation strategies, although multi-criteria analysis is not without its own drawbacks.				

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			- There is a strong philosophical following for the use of low social discount rates for discounting future consumption, and a strong practical following for the use of rates nearer market levels. Trying to value the effects of foregone investment on future consumption is complex and possibly subject to manipulation. It is hard to justify lower discount rates for this particular type of social investment than for the many other types of investment that are currently made. Faced with this dilemma, some analysts have chosen compromise rates between these positions. An alternative is the use of multiple discount rates by analysts. The implications of this approach, with all results provided to other analysts and policy makers, might usefully be addressed in this chapter. 8. Firms and Planets. The authors conflate the use of a perfectly usable framework about decisions within a firm or public agency with a program of planetary management. We need to distinguish between the means to achieve efficiency through markets or their surrogates, and the things that make markets possible--their preconditions. In "The Cultural Contradictions of Capitalism" Daniel Bell argues convincingly, to me at least, that capitalism depends on certain virtues (e.g. thrift, hard work etc.) that it tends to erode. Surely the earth's basic systems such as climate are candidates for being among market preconditions, and are being disequilibrated by unconstrained markets. 9. GNP a Mismeasure of Man. The problems with the GNP (p. 21) measure are far more extensive than even the literature on its defects (e.g., corrections for capital depletion, defensive expenditures and the like) recognizes. None of these revisions deals with the underlying problem that it embodies far too narrow a conception of human well-being to begin with, because it focuses too much on consumption. A much more promising way of thinking is being developed by Nussbaum and Sen entitled the capability approach. see, for instance, The Quality of Life. They argue that there a generic set of capabilities that define the good life, and that consumption is instrumental to only some of them. This grounds Sen's claim that development as normally understood is a result of conceptual and moral failures. IV. Editing and Clarification All but one of these points are noted in the specific comments on the chapter. 1. My comments will likely point out which parts of this chapter are unclear to a				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			non-economist. This chapter sometimes provided clear explanations of relevant concepts and other times used cryptic economics shorthand that I was not able to follow				
1	1	14	Why is the alternative chapter posited? If efficiency is an important consideration in discounting - and surely it is - then it should be mentioned in the actual title and should get adequate treatment in the chapter.	USA	32	G	
1	2	24-26	Agreement on this is not widespread.	NED	09	G	
1	2	33-34	Literature on the growth of green GNP (Repetto, Hueting) sometimes comes up with growth rates over the past decades of -0.5 to -3%.	NED	09	G	
1	2	10-11	The choice of words "collapse of future" could have a wide range of interpretation depending upon a readers frame of reference. Suggest text read instead: Such results make clear how difficult it is to draw quantitative conclusions from calculations based on such long time horizons.	IPIECA	18	A	
1	2	7-11	The reviewers find that the example given here is very effective in driving home the importance of discount rates in the context of climate change. We would encourage the use of more examples of this type in this chapter.	CAN	24	G	
1	2	11	The flip side of the collapse of future values due to discounting is that very small displaced investments can lead to very large future shortfalls in output.	USA	32	G	
1	2	28-34	This generalized egalitarianism seems to have to do with transferring wealth from the rich to the poor (utilitarianism) and seems logically unrelated to intertemporal or intergenerational trade-offs. It just so happens that future generations are expected to be wealthier than the present generation. Does'nt this assumption need to be considered in constructing our scenarios of the future?	USA	32	G	
1	2	38	The implication that markets do not effectively allocate goods over time (and particularly over generations) is controversial. It affects more than global warming policy and raises significant questions about national savings policy and use of exhaustible resources. Do not believe there is a consensus among economists that market interest rates are generally incorrect guides to behaviours in those settings.	USA	32	G	
1	2	40-44	How, exactly, are intergenerational trade-offs for environmental goods different from those for private consumption goods? Converting environmental goods to their	USA	32	G	

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			equivalent in private consumption goods would seem to ensure that these two types of trade off are treated equivalently, not differently.			
1	3	9-11	The reviewers agree with this point.	CAN	24	G
1	3	8	What is the "incremental component" of the discount rate? Is this the idea that risks compound over time? If so, why would we not want this aspect incorporated into the discount rate?	USA	32	G
1	3	13	How can certainty equivalents be used to treat issues of equity?	USA	32	G
2	3	42	It is argued that most countries pass the weak sustainability criteria. Believes that this conclusion is based on Pearce's compilation of estimates a couple of years ago. These estimates are highly uncertain, inherently complex and difficult.	SWED	17	G
2	3	35	The sustainability school of thought as outlined by: Pearce, D.W. and R.K. Turner (1990), Economics of Natural Resources and the Environment, Harvester Wheatsheaf, London, is an important published school of thought in respect of intergenerational equity and could be added to the text. Add: The extent to which natural and cultural resources are substitutable is critical to this analysis and is highly contentious. Many economists including Pearce and Turner (1990) stress the need for sustainability limits to guide natural resource use which will be needed by, but cannot be created by, future generations.	AUST	23	G
2	3	37-41	Good point.	CAN	24	G
2	3	21	The compensation problem deserves some discussion, it is relevant for any discount rate.	USA	32	G
2	3	33	Why "must" discussions of intergenerational equity go beyond sustainability? Brown-Weiss, for example, implies that sustainability is a "legal" (though perhaps more accurately, "a plausible ethical") obligation that generations face. What evidence is there of a consensus that governments should be allowed to make poorer generations suffer so long as richer generations gain sufficiently? Arguably this view is controversial, yet it is implicit in the utilitarian framework that drives the equity analysis of this chapter. While this framework is important and merits exploring, it should be made clear that this is not the only possible framework. It should also be explained to policy makers that despite the technical content of this discussion, the material covered is quite normative, and that while economists have expertise in	USA	32	G

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			analyzing these norms, they are not in a position to determine them for society.			
2	4	14	According to Chapter 3, Rawls is a utilitarian.	NED	09	G
2	4	0	It should be noted that Rawls himself argues that the maximum criterion should not be applied to intergenerational problems (Rawls 1991).	SWED	17	G
2	4	10-19	Contrast between utilitarianism and min-max is well summarized.	USA	32	G
2	4	21-35	Re. Schelling's dissenting opinion. Distributional considerations can be incorporated into utilitarianism. Distributions affect individual utility by way of perceptions of fairness and emotions such as envy. (see also p. 5, lines 9-18).	USA	32	G
2	4	0	Re. Box. The discussion of Schelling's view is too abstract to be useful to policy makers. Regarding the conclusion in the Box, it is not obvious that the analyses presented in the chapter-- which, in effect, suggests consumption transfers across generations to help equate marginal utility -- is appropriate in a world where richer nations make only modest transfers to poorer ones.	USA	32	G
2	5	12	The sentence on Thurow's paper should probably be moved to later in the para.	USA	32	G
2	5	20-26	If environmental outcomes are not discounted, but other outcomes (eg, financial ones) are, certain inconsistencies will result such as preference reversals (see Keeler and Cretin, 1983). This is certainly a consequence of "special treatment" that should be pointed out to policy makers.	USA	32	G
3	0	0	The following comments are applicable to Chap. 4, sections 3.3.1 and 3.7, chap. 6, sections 6.1.2 and 6.1.3, and p. 7 of the PMS. The use of discount rates assume that investment is made at time "t" and the yield would come sometime in the future. It applies to marketable goods and services. The choice of discount rates may be extremely difficult in addressing environmental goods and services. This is true, particularly, to non-marketable goods and services. Non-marketable goods and services may represent secondary, tertiary, etc., indirect or derived costs and benefits of economic activities. In fact, ecologists have argued that that the environmental value of non-marketable goods and services may represent the largest portion of environmental damages, more so of their cumulative effects. It is	CAN	24	G

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			suggested in the report that the relative prices of environmental services is unlikely to rise and thus the effective discount rate can be lower than discount rates used for goods (marketable?). This is particularly troubling issue. Considering the fact that there are limited information on ecological effects of GHGs, and the need to account (value) for non-marketable goods and services, the assumption of declining/constant price or discount rates is questionable.				
3	5	30	The discussion in the prior section is also prescriptive.	USA	32	G	
3	5	37-44	See comment re line 30. Would not the answer to these three questions be the same, because of the inconsistencies that result from using different discount rates for different outcomes?	USA	32	G	
3	6	0	The five points put forward here are clearly stated and well argued.	USA	32	G	
3	6	7-10	Why is this argument limited to benefits accruing to the same generation? The whole idea of utilitarianism is that utility can be traded off across people.	USA	32	G	
3	6	38	Should add the following sentence to this para.: "However, given appropriate estimates of relative prices, there is no reason to explicitly modify the discount rate."	USA	32	G	
3	7	0	The reviewer has doubts on whether the formula is correct. Seems to be too simple. It presumes that welfare is so well-defined that one could take the first derivative to consumption. This is doubtful at least, as it is doubtful that, could it be done, "v" would be a constant as is suggested. But if it could be done, why would one be happy with the first order Taylor approximation? Global change is hardly a local problem.	NED	09	G	
3	7	20-24	"If the project displaces private investment that has a high marginal productivity...The prescriptive view takes into account opportunity costs in calculating changes in consumption, but in valuing the changes in consumption, uses the SRTP." It appears that what is being said is that, where mitigation projects displace other investments, future consumption must be reduced by the consumption that the displaced investment projects would have generated. It is net consumption that is to be discounted with the social rate of time preference. This appears to be a compromise between using low social discount rates throughout the analysis and using the opportunity cost of capital throughout the analysis. It is not clear however, what one does in practice. The suggested discounting method is both confusing and subject to manipulation. Specific examples are required to aid clarification.	IPIECA	18	A	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
3	7	3	The social welfare function and related relationships used to derive this equation should be stated explicitly. It is the most important equation in the chapter but has not clearly been derived for readers. A reference to the annex and a full presentation there would be useful.	USA	32	G	
3	7	8-14	Throughout the chapter it is unclear about the relationship between the SRTP and the market interest rate. Is SRTP meant to express discounting above and beyond discounting because of investment opportunities? Investment opportunities (leading to a particular market interest rate) presumably exist because of economic growth, g. So why is g so much smaller than current interest rates? (see also p. 12, line 38 to page 13, line 8.)	USA	32	G	
3	7	20-24	"If the project displaces private investment that has a high marginal productivity... The prescriptive view takes into account opportunity costs in calculating changes in consumption, but in valuing the changes in consumption, uses the SRTP." Believe what is being said here is that, where mitigation projects displace other investment, future consumption must be reduced by the consumption that the displaced investment projects would have generated. It is net consumption that is to be discounted with the SRTP. This appears to be a compromise between using low social discount rates throughout the analysis and using the opportunity cost of capital throughout the analysis. However it is not clear what one does in practice, and am concerned that the discounting method suggested will be both confusing and subject to manipulation. Any investment can be argued to displace some other investment that would generate (at least) the opportunity cost of capital. And that investment will yield returns, some of which will be re-invested. The suggested procedure may be better in concept than in practice. If this procedure is to be proposed, specific examples are required for clarification.	USA	32	G	
3	7	44	This is the only reference to Loewenstein and others on decision biases in intertemporal choice. In addition to the common difference effect cited here (lower discount rates for longer delays), descriptively, discount rates are lower for large magnitudes, for losses compared to gains, and for sequences over outcomes, compared to individual outcomes. Finally, temporal discount rates expressed in decision-making experiments are typically 50% annually or more, much higher than those discussed in this chapter. What implications to these findings have for potential climate change policies and the success of their implementation? One implication might be that because many people have personal discount rates much higher than those suggested in this chapter, they would be uncooperative with the resulting policies. Am not familiar	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			with psychological work looking at intergenerational decisions however (but see Lipscomb, 1989).				
3	8	0	As stated elsewhere in this chapter, should'nt risks, such as the small change of human extinction, be incorporated into a certainty equivalent, which would then be discounted?	USA	32	G	
3	9	19	The finding that the optimization problem is not well defined should be further elaborated.	USA	32	G	
3	9	24-35	It is not clear why these knife-edge results occur.	USA	32	G	
3	10	9	Do not share the opinion that it be viewed as a "problem" with utilitarianism. The normative status of utilitarianism is independent of descriptive behaviour(such as the unwillingness of people to make large sacrifices to benefit future generations.)	USA	32	G	
3	10	38-41	This is biased. If one discounts outcomes from generation 1 to generation 2 much more than for generation 101 to generation 102, one is not exhibiting constant discounting. Although someone in generation 1 may view a benefit delivered to generation 101 as equivalent to the same benefit to generation 102, someone in generation 101 would not have the same view. This illustrates the preference reversals that result from non-constant discounting. The comment about the empathetic distance suggests the need to clarify how the discounting is grounded in a particular time period. Also, other social science research shows that there are markedly different cultural views on concepts of time that affect behaviour.	USA	32	G	
3	11	22	Insert "absolute value of" before "elasticity".	USA	32	G	
3	11	26	Are the low rates of productivity a US phenomenon or applicable to the world?	USA	32	G	
3	11	38	See this reviewers comment for p. 11, line 22.	USA	32	G	
3	12	11-12	This statement does not seem right. A very high theta (say 50) would imply that one requires an incredibly high rise in the next generation's per capita consumption before one would agree to a small decrease in one's own generations's consumption - not very equitable. Instead higher values of theta seem to imply more selfishness, lower values imply altruism, and some intermediate values imply equity.	USA	32	G	

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
3	12	11	What is meant by "The more weightequity." there are all kinds of equity criteria, each with different values of Q. One view of equity would be very protective of worse off generations; another might be less so.	USA	32	G	
3	12	27	While there are a number of equity reasons to intervene to help the very poor, the idea that government should fine tune the income distribution is less clear. At some point government intervention can cause inefficiencies and can run into other equity problems such as those associated with confiscation.	USA	32	G	
3	12	40	Should "even" be "particularly"?	USA	32	G	
3	13	12-17	Where do these specific discount rates come from?	USA	32	G	
3	31	0	Needs further elaboration.	NED	09	G	
4	14	13	Shouldn't one state that based on "certain" ethical grounds, it is tough to support the higher time preference rate?	USA	32	G	
4	14	15	What is OECD?	USA	32	G	
4	15	30	Replace "most plausible discount rates" with "discount rates below 10 per cent". The presentation of the example does not follow the methods advocated by the chapter. The authors should carefully construct an example that demonstrates the various discounting approaches discussed in the chapter, including all their steps.	USA	32	G	
4	15-16	0	The meaning of "institutionally infeasible" is not apparent as cited in reference to option d. An explanation needs to be provided.(p. 15) Re. p. 16, lines 43-44. The prescriptionists response for using low discount rates seems rather weak as presented here. Are there any other arguments that would make their position more credible?	IPIECA	18	A	
4	16	9	The estimate of a 15.1% real return to non-residential capital over the period 1975-90 seems very high. The estimates should be properly attributed to their respective authors.	USA	32	G	
4	16	33	Wouldn't general economic growth address a large share of the damages from	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			warming? Moreover, compensation of future parties that lose from particular policy choices is difficult regardless of the discount rate chosen.				
4	16	33-35	Replace the last two sentences with the following: "Society may not be willing to make other investments, for example in education and research, which could reasonably be expected to benefit those adversely affected by climate change, even hundreds of years in the future. Even if society were willing to make such investments, there is no guarantee that their rate of return would remain where it is today over this entire time period."	USA	32	G	
5	0	0	The conclusion that it is not appropriate to discount for risk or uncertainties is correct.	SWED	17	G	
5	17	1	The existence of multiple market failures is a classic problem of the second best. It is not obvious whether piecemeal fixes would make things better or worse.	USA	32	G	
5	17	19	Footnote 3 is unclear. Risk aversion (declining marginal utility) is supported by data, for example. Agree that it is not clear what the authors are saying about data. Also, what about the data that shows risk loving over losses? Is GCC a problem of losses or gains? Footnote 2 is also unclear. Does "G" refer to the public good? If so, it is not defined until 7 pages after the endnote shows up.	USA	32	G	
6	18	17	If there is no intertemporal welfare maximization by the government, then how can one assert that market rates are necessarily wrong? Couldn't the lack of intervention be viewed as an endorsement of market rates?	USA	32	G	
6	18	21-30	It is unclear from the text just what a shadow price is.	USA	32	G	
6	18	29	The work presented by Lyon at the IPCC meetings show that a shadow price of capital of 1.5 to 2 may be quite low, given the rates of time preference assumed by Cline and others. For example, with no reinvestment of capital income(except for coverage of depreciation), a rate of time preference of 2%, and a return to capital of 8%, the SPC will be 4.0. If 10% of net returns to capital are reinvested, the SPC rises to 6; and if 20% of net returns are reinvested, the SPC rises to 16. Moreover, if the rate of time preference is 1.5% - as is argued several times in this chapter - then the SPC under the last set of assumptions would be infinite. (Note that the total weight on costs will be below these values, as only the portion of costs coming from investment gets weighted by the SPC).	USA	32	G	

WGIII Peer Review

March/24/1995

Page: 29

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
6	19	1	The relationship of the discussion in this Para. to the shadow price of capital approach is unclear.	USA	32	G
8	21	5-6	The statement that most evidence from economic history suggests the possibilities for economic substitution is high could be misleading. First of all, there are a number of cases from economic history which point in the opposite direction. eg. the rapid protection of the ozone layer, the conflicts over water scarcity etc. secondly, it does create the impression that "no single resource is indispensable" but it is obvious that there might exist several essential functions of nature which life can not be without and which we can not compensate for. Thus the burden of proof lies on those those who claim that substitutability is possible in all cases since they put the rest of humanity in jeopardy.	SWED	17	G
9.1	23	24	This derivation of the discount rate needs further elaboration. Equation 4A.1 should be maximized, and the relationship of the interest rate to this equation should be explained.	USA	32	G
9.1	24	4	Again, intergenerational equity can be far more complex than determination of Q.	USA	32	G
9.1	25	20	Again, the discount rate would not be negative if prices are appropriately adjusted. See this reviewers comments on p. 6, line 38 of this chapter.	USA	32	G
9.1	25	23	The relationship of the Sandmo-Dreze approach to the SPC approach is unclear.	USA	32	G
9.1	26	7-11	The point being made here is not very clear.	CAN	24	G
9.2	27	17	Should the statement refer to $G=U$ or G not equal to U ?	USA	32	G



UNITED STATES OF AMERICA

UNCLASSIFIED
TELEFAX TRANSMITTALDATE: 3/28
TIME: 3 pmTO: J. Stiglitz (in care of Lisa Branch)
(Name & Office)FAX NUMBER: 202-395-6853
(Country code + City code + Fax #)Transmittal + 4 pagesFROM: S. Kane
(Name, Office, Agency Code)

EMBASSY PARIS ()

Unit 21551

APO AE 09777-12-2222

TEL: 33-1-4006-1500 ext. _____

FAX: 33-1-4266-9783 or _____

AMBASSADE DES ETATS-UNIS

2, Avenue Gabriel

75008 Paris - France

(1) 42.96.12.02 poste: _____

(1) 42.66.97.83 ou _____

SUBJECT: TPC Meeting of W&III (Paris)REF: Report on Paris Meeting and

Page
1

MESSAGE:

The meeting was productive but a lot of work remains. No one from the chapter 4 and 5 teams attended (discussing cost-benefit analysis) so those topics were not discussed. ^{most} of the scope writing team attended; Jose Goldenberg and Ray van the meetings of authors. Most of govt comments can be handled relatively easily.

The theme of going beyond "no regrets" was discussed at length in the plenaries and score meetings. I would recommend strongly that the score writing team draft a clear definition (along with alternative points of view in footnote) and submit to the Bureau for use in the summary for policy makers.

(*) I am returning on Thursday 30th and will come in to the office on Friday. I am at the Hotel Vantheon 43-54-32-45 voice

NOTE: ADDITIONAL SHEETS MUST BE OF BOND PAPER OR PHOTOCOPIER PAPER WEIGHT --

-- TRANSMISSION TIME: COST: AGENCY CHARGED:

EMB-35 / October 93 (0119Vpage66)

Page 2

Three major problems persist.

I. Peri Bolin seems totally uninformed about the material in WG.3. He is trying to defend the science of climate change from various attacks (the most recent in Nature) and seems particularly distrustful of integrated assessment efforts and research claims. His understanding of the role of economics will become increasingly important when the "synthesis" report is drafted!

II. The authors of WG.3 are confused about the responsibility for drafting the summary for policy makers. Most would like to see it re-written but a lack of consensus remains over what to put in it and the exact rationale for "going beyond no regrets" theme. The WG.3 Bureau took the US' suggestion to order the material by chapter. The content of CIRA section was not discussed and needs to be worked out with the Bureau.

(X) III. Only 1 author ^(fig) Ch. 2 (decision framework) came to Paris meeting. Many lead authors volunteered to help with decision making under uncertainty portion but little progress was made in developing a strong work plan to get the chapter re-written. Jyoti Parikh is quite ill; she did not attend the meeting. Her material is widely held to be of very poor quality but politics will not allow her contribution to be dismissed/deleted. No number of experts to work on that material surfaced at the meeting. We will need to play a continuing strong role in getting this chapter completed adequately.

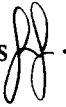


INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

145 King Street West, Suite 1002, Toronto, Ontario M5H 3X6 CANADA
Tel: (416) 369-0900 Fax: (416) 369-0922

MEMORANDUM

TO: Dr. William Cline
Dr. Joseph Stiglitz
Prof. Ken Arrow
Dr. Mohan Munasinghe
Prof. Karl Goran-Maler

FROM: Dr. Erik Haites 

RE: Comments on Chapter 4

DATE: March 24, 1995

Here is a complete set of comments on Chapter 4 for your review. We have also enclosed a diskette copy in WordPerfect 5.1 of this.

We would like to have another draft of your chapter for review by the Bureau by April 24. If possible, please provide an electronic copy (WordPerfect 5.1) of the revised chapter.

Chapter Four

WOMEN **Governments/Organizations** **Review of the Second** **Assessment Report**

Chapter 4: INTERTEMPORAL EQUITY AND DISCOUNTING

4.0	General Comments and <i>Summary</i>	<i>ii-iii</i>
4.1	Introduction	1-3
4.2	Intergenerational Equity	3-5
4.3	Discounting and the Social Rate of Time Preference	5-14
4.4	Formulation of Descriptive Approach	14-17
4.5	Discounting for Risk	17
4.6	Producer or Consumer Interest Rates?	17-19
4.7	Discounting Environmental Impacts	19-20
4.8	Implications for Sustainable Development	20-22
4.9.1	<i>Annex 4A</i>	23-26
4.9.2	<i>Endnotes</i>	27
4.9.3	<i>References</i>	28-33

Reference			Comments	Reviewer (Country #)	ID	Response
Section	Page	Line				
04 Intertemporal Equity and Discounting						
0	0	0	This is a clearly written and rigorous exposition of discounting and inter-temporal equity. Is this topic, covered in 32 pages including references, of sufficient interest to policy makers and government delegations to form part of the main SAR? As a paper in a separate volume of Technical Papers it would have greater merit (some material in a few other chapters could be similarly handled). This material is familiar enough to those who follow the relevant academic literature, but there is widespread feeling that economists in this area wax over-long and over-enthusiastically on discounting and discount rates. The essence of the topic could be adequately covered in 2 or 3 pages and go into a slightly expanded section in Chapter 5 (pp. 32-33) or Chapter 6 (section 6.1.5 at p. 7). This proposal should not be viewed as a negative comment, but a reflection of the subject matter and its prioritisation for most potential readers. A box might have been prepared which summarised why some people are deeply opposed to the application of discounting (or maximisation of net present value) to intergenerational and other sustainable development issues.	WEC	01	A
0	0	0	It seems that the scientific information and the more personal views of the authors are not clearly separated. There is an obvious lack of coordination between chapters three and four. The key message seems to be that there are several arguments for choosing a high discount rate or a low one; the final choice is really up to the policy-makers. More attention could be paid to the (especially moral) implications of using a discount rate. The differences between prescriptive and descriptive need to be clearly stated.	NED	09	G
0	0	0	Re. page iii, line 12. What is the scientific basis for these numbers? Suggest deletion.	NED	09	G

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
0	0	0	General Comments	SWED	17	G	
			1) with strong arguments against using a non-zero pure rate of time preference can not see why a zero or at least a very low rate is not recommended in the text. 2) Discounting due to an expected increase in per capita income in the world is discussed and it is recognized that the relative per capita growth need not be constant over time. If it declines over time it implies that also the discount rate should decline. In combination with a low or zero rate of time preference, this has considerable implications for how impacts occurring far into the future are valued. This should have been illustrated in a diagram as well as mathematically. (See attachment)				
0	0	0	While it is true that "identifying the proper discount rate is probably the single most important analytical step in the economic analysis of climate change", the cited sentence might create the impression that one can analytically derive a value for the discount rate. This is impossible because one component of the discount rate must be determined by the pure time preference, must be determined by ethical considerations. Thus it should be stressed that (i) the discount rate is to a decisive extent determined by ethical considerations and (ii) the choice of crucial importance for the cost analysis of climate change.	SWED	17	G	
0	0	0	Can this issue meaningfully be expressed as a discounting problem? Much of the benefit that will take place far in the future cannot reasonably be estimated, it involves health and ecosystem effects which are ill-defined and whose valuation is uncertain and controversial. This suggests that a multi-criteria approach to the problem is more suitable. Suggest organizing the chapter along the following lines: - Economics provides no clear answers to many of the issues raised by discounting in this situation. There are strongly held views on all sides of the question. - The use of MCA provides an alternative to trying to discount the future benefits of current climate change mitigation strategies, although MCA is not without its own drawbacks. - There is a strong philosophical following for the use of low social discount rates for discounting future consumption, and a strong practical following for the use of rates nearer market levels.	IPIECA	18	A	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			Trying to value the effects of foregone investment on future consumption is complex and possibly subject to manipulation. It is hard to justify lower discount rates for this particular type of social investment than for the many other types of investment that are currently made. Faced with this dilemma, some analysts have chosen compromise rates between these positions. An alternative is the use of multiple discount rates by analysts. The implications of this approach, with all results provided to other analysts and policymakers, might usefully be addressed in this chapter.				
0	0	0	Re. p. ii, lines 3-7. The recognition that this is a philosophical and ethical question as well as an economic one is important. However, this also means that there can be no one right answer to the discount rate question. To communicate to policymakers the necessary absence of a "proper answer" to this question is important in an assessment of economic knowledge to the climate change question. Re. p. ii, lines 31-32. Consistent with the comments on lines 3-7 by this reviewer, avoid implications of there being a proper answer. Re. p. iii, lines 30-32. The authors should be complemented for their efforts to include views of the discount rate, such as those held by Schelling and Nordhaus, which are different than their own. However this summary gives short shrift to the "descriptive" approach. The implication of a trust fund earmarked for greenhouse victims seems extreme. The summary lacks discussion on sections 4.5 to 4.8.	IPIECA	18	A	
0	0	0	Overall this chapter is comprehensive, balanced and reasonably well written survey and evaluation of the available literature. Moreover, the chapter summary was in general a fair representation of the body of the text and was, in turn represented effectively in the PMS. Each of these aspects of the text should therefore be supported against any attempts to substantially amend them. The chapter summary and more importantly, the policymakers summary, does not adequately represent the treatment in the text of the alternative approaches to discounting, on the one hand, and the (affordable) safe minimum standards/natural capital approach on the other. This could be done and injected into the chapter on discount rates.	AUST	23	G	
0	0	0	There is a danger in assessing the impacts of climate change that assessors will consider the issue as but one other "project" and rely on existing literature about	CAN	24	G	

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			discount rates and their optimal levels. The problem of climate change is a very long-term "project" and as stated in this chapter discounting is one of the critical issues in assessing its costs.			
0	0	0	This chapter seems rather esoteric and much of it is unintelligible.	CAN	24	G
0	0	0	Re. p. ii, lines 32-34. The intergenerational equity questions are profound. GHG stabilization objectives may require substantial abatement by some of the world's poorest countries. Some of the benefit of these abatements will accrue to the wealthy. Vulnerability to climate change may be the greatest in the poorer countries. Questions about how to share the costs of abatement and distribute climate change damages are no easier to resolve than those regarding intertemporal questions. This should be handled by a clearer sense of the relationship between chapters 3 and 4.	USA	32	G
0	0	0	Re. p. iii, lines 28-32. The authors argue that the proceeds of market investments are not likely to be set aside to compensate those adversely affected by climate change. The implication is that market rates of interest, or opportunity cost of capital, are inappropriate for discounting future benefits of climate investments. The argument is not convincing. While investment proceeds are unlikely to be set aside directly for the exclusive use of climate change victims, market investments will benefit individuals in the future, even the distant future. The opportunity cost of climate investments include foregone investments that would augment human and physical capital. Augmentations to the stock of human and physical capital will expand capacity to produce consumption goods in the future, thereby benefiting future generations. In fact, the industrial age has witnessed an extraordinary increase in wealth and living standards as one generation inherits capital from the previous generation and leaves a larger stock of capital to the next generation. Also note that, although little physical capital from the dawn of the industrial age has survived to the present, no one can doubt that investments made at that time yielded benefits that still enrich us today, two centuries later. These benefits accrue to us today even though no one thought to earmark and reserve them for the end of the 20th century. Given the history of the creation of wealth over the past 200yrs, it is puzzling that the authors dismiss the possibility of adding to the wealth of future generations through investment in any projects but those that mitigate climate change. If this hypothesized inability to benefit the future by current investment is the sole argument against use of the opportunity cost of capital as the discount rate, then this criticism does not seem to	USA	32	G

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			be fatal. Use of the opportunity cost of capital as the discount rate would seem to be a defensible position. The chapter, which gives far too little attention to the opportunity cost of capital approach should be revised to correct this deficiency. However, we should be careful when thinking about our assumptions regarding the motives of past generations and their sense of moral obligation to us.				
0	0	0	Re. p. iii, lines 30-32. The authors should be complemented for their effort to include views of the discount rate, such as those held by Schelling and Nordhaus, which are different than their own. However, this summary gives rather short shrift to the "descriptive" approach. In particular, the implication that society needs to set funds aside, as in a trust fund, earmarked for eventual compensation of greenhouse victims seems extreme. So long as funds are invested productively, they will be available to future generations. Incremental economic growth provides the resources for future compensation for future victims. Compensation is really a redistribution problem for future generations, which can not and should not be solved now.	USA	32	G	
0	0	0	Page ii Summary, Lines 3-7 The recognition that this is a philosophical and ethical question as well as an economic one is appropriate and important. However, this also means that there is a range of advice based on different prescriptive and descriptive considerations. To communicate to policy makers the necessary absence of a definitive answer to this question is important in assessment of economic knowledge as applied to the climate change question.	USA	32	G	
0	0	0	Page ii line 20 How accepted is the Brown-Weiss argument? My sense is that it is not supported by any treaty. Rather it is more an ethical norm. Does terming it an international legal principle give it more weight than other philosophical criteria (eg. Rawls' difference principle or Nozicks theory of rights)?	USA	32	G	
0	0	0	COLLATED COMMENTS IPCC WORKING GROUP II DRAFT ASSESSMENT Chapter 4: Intertemporal Equity and Discounting Lead Reviewer's Overall Summary and Comments for Review Process:	USA	32	G	

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			The chapter lays out the central issues of the longstanding discounting debate in economics somewhat independently from the specific program of global climatic changes (GCC). What connections there are to GCC are made strictly from the view of largely deductive economic theories. The chapter attempts to distinguish a "prescriptive" and "descriptive" as a way of introducing a more inductive approach but then seems to reject this view on "ethical" reasons. This is somewhat surprising, since the ethical arguments mentioned are more a matter of practicalities (ensuring future transfers) than they are a genuine consideration of moral obligations (e.g., stewardship). Of central concern is whether or not the chapter conveys to policy makers what they need to know to make informed choices regarding the discount rate for policy analysis in GCC. I think there are several serious problems here: I. The chapter fails to consider the more fundamental issue of the nature of the problem. As one reviewer points out, the authors proceed as if all the consequences can be framed as a gradual process of incremental damage. Under these conditions, the problem collapses to a debate over rates that may be of great interest to economists, but I believe will be regarded by policy makers as missing the point. In contrast, another reviewer faults the chapter for treating GCC as a special case. While I am inclined to believe it is, for a number of natural and social scientific reasons, I agree that the authors have not made the case here. The chapter should begin with a clear essay on why GCC is or is not different from any other policy concern. For example, the chapter states that future generations can be compensated for "some" environmental/natural resource effects, but what about the "and not for others" case? This should be followed by a discussion of the significant views of "better off" that would be at the core of alternative normative perspectives for this problem if we were to treat it as a special case. The relationships between Chapter 3 and this chapter should be clarified. II. The economic perspective should receive special attention, but the authors should carefully delineate normative and positive results. Policy makers will want to know when prescriptions are based on normative models (some of questionable empirical validity), and when they are based on credible scientific evidence. The chapter's distinction between "prescriptive" and "descriptive" approaches is misleading. In fact, both approaches are prescriptive; however, one is based on a largely deductive methodology while the other is more inductive. Both approaches are often at odds with empirical results in decision making and market behavior in the case of unfamiliar or poorly defined goods (and these major results should be made clear for policy			

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			makers). What the authors present as an "emerging consensus" regarding discounting is clearly not one, given the reactions of the reviewers. III. Very little discussion is devoted to the implications for policy analysis in the real world. As examples, the chapter does not offer insights for sensitivity analysis, scenario development, or alternative treatments of the problem as might follow from specific stabilization policies. Contrary to the tone in the SUMMARY which endorses cost-effectiveness analysis (but not cost-benefit analysis) and a variety of ethical principles for addressing equity, the tone in this chapter emphasizes finding the "correct" rate of discount to decide about alternative policies. The chapter seems determined to make a single recommendation, rather than explicating reasonable alternatives that reflect different normative commitments and preferences. In addition, the chapter should more carefully distinguish the interesting cases of this problem: policy choice, project choice given a policy goal, catastrophic risks, and cooperative and non-cooperative policy strategies. IV. Key concepts and examples need clarification and editing. Some examples are confusing, key concepts are introduced with little definition, abstract methodological concerns are raised but not explained, and, as currently written, the annex does little to resolve concerns about the normative perspective or its empirical grounding. To help the authors think about revisions, I have organized all of the general comments under the four categories discussed above. In some cases, I have appended to a comment from a reviewer some additional concerns of my own. The specific comments are ordered by page and line number, but the category concerns are noted there as well. General Comments on Chapter from Reviewers: I. Intertemporal Equity 1. The Inappropriateness of Discounting A. Assuring Climate Change. Since the costs of averting change occur in the present, and the benefits in the perhaps distant future, discounting dramatically devalues the future values associated with it. Ironically, if we assume a smooth warming path with slowly accumulating net damage (as these authors do for the most part) then the adoption of this framework alone constitutes the decision to do nothing. There is no need for any analysis within it. This assures that the goal stated in the "Summary for			

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			Policy Makers" of "stabilization of greenhouse gas concentrations" will never be met. The conclusion is such a short inference away from, and so completely determined by, the (unjustified) assumptions of the method that the whole thing seems silly. B. Immortal Agents. The authors are quite mistaken to brush aside Tom Schelling's criticism that long term discounting assumes an immortal agent. Surely Schelling is right that there is a world of difference in thinking about my own future consumption and that of others. This difference causes the whole framework used by this chapter to collapse. The authors have conflated issues of allocation with those of distribution. This is completely illegitimate. C. Time and its Correlates. Further still, the idea of discounting is far more problematical than normally assumed by these authors. As Derek Parfit has argued, discounting typically confuses things that are correlated with time, with time itself. A variety of arguments are offered in support of discounting: risk, opportunity costs, the supposition that future generations will be better off than we are, etc. But in none of these cases, is it time itself that is the key issue. These authors exhibit these confusions in numerous places including pages 9,11 and 17. D. Time Preference. We would think much more clearly about the future if we used a disaggregated vocabulary rather than starting with the assumption the there is a social discount rate. I think that there are also reasons to doubt that individuals have a rate of time preference; or at least, that it functions in the broad way that economists assume. For example, why must present and future time value be related by an exponential function? Why not some other relationship? What is referred to as time preference needs to be disaggregated in much the same way as "the" social discount rate. See, for example, Rawls' discussion of this subject in A Theory of Justice. 2. Problems with the Point of Departure A. Distributing Utility. The authors are quite mistaken in thinking that the issue is the distribution of utility. Utilitarianism has been virtually universally rejected by philosophers, but the authors seem unaware of this literature. Their statement (page four) that their approach derives from a "persuasive axiomatic structure" hovers somewhere between irrelevant and outrageous. They seem uninterested in the questions of whether the system is true or not. Who cares if it is axiomatic or not. The utilitarian project has failed utterly to offer a satisfactory account of moral obligation.				

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			- Utilitarians have been unable to show how to get from the (I believe false) proposition that everyone seeks to maximize their own utility, to the idea that we have a moral duty to maximize the utility of everyone. - In offering no place for the language of rights (Bentham referred to rights as "nonsense, nonsense on stilts") it authorizes the ruthless exploitation of the minority if we can show a net gain of utility. - It is infeasible from a motivational point of view in the classical version (greatest happiness of the greatest number) because it requires more altruism than we can reasonably expect people to muster. (Further, it is mathematically impossible to maximize two variables.) The self-interested motivational assumption of the neoclassical school fails for the opposite reason in that it fails to offer any account whatsoever of what we owe one another. The attempts on the part of modern economics to distance itself from the failure by dropping the language of utility in favor of that of preferences backfires. If preferences are not connected to utility then it is completely mysterious why one should care about them. Incidentally, a utilitarian should consider the preferences of at least some nonhuman animals since many of them can also experience pleasure and pain. B. Finding a Foundation. Not all goods are, or should be, tradable at the margin. Coase type transactions cannot go all the way down--otherwise we would have to bribe people not to assault us. The way all societies actually function is to block a set of exchanges and then allow Pareto transfers above those constraints. In our society, for example, votes cannot be legally marketed, nor can certain fiduciary goods like national battlefields. C/B analysis sheds no light on which exchanges should be blocked. One might reasonably assume that exchanges that impair the earth's life support systems should be blocked as we have done in the case of ozone depleting chemicals. 3. An alternative point of departure: Trusteeship The authors seem to misunderstand the trust model (p. 3) in that they imply that it allows for perfect substitution. Here they conflate technical with moral substitutability. The conventional efficiency/equity distinction is dysfunctional because it misunderstands the nature of goods. A. Problems with the Efficiency/Equity Distinction. In the standard view there are two			

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			objectives for policy: efficiency, to be achieved by corrected markets; and equity which is usually not very robust- but is either a constraint on efficiency or is some ways to be traded off against it. There are a number of problems which go way beyond the one normally recognized: that economics doesn't have much to say about equity. First, the basic distinction does not parse at the joints. The idea is that there are goods traded in corrected markets that yield efficiency makes it sound as if there is only one or two kinds of goods. But Walzer is certainly correct in Spheres of Justice in his observation that goods move in accordance with their meanings as much as with their prices. There are at least four different classes of goods in all societies: 1) those traded in markets; 2)those distributed according to merit--public office, licenses to practice medicine and the like; 3) those distributed according to need--e.g. food stamps; and 4) fiduciary goods which one generation preserves for those who follow. (My argument is that because of its role in the preservation of species and cultures that climate is a good of this kind.) Seen from this perspective the role of public policy is the proper maintenance of these various spheres--not the maximization of utility or consumption in one of them--the market. Market Preconditions. Once we distinguish between markets and their preconditions the question arises of how should we think about those preconditions. In Restoring the Public Trust I argue that a fiduciary model captures what is at stake with respect to climate change. This grounds, I believe, an obligation to leave the world at least as good as we found it--meaning leaving its productivity and diversity intact. Because of the role of climate change in species extinction, and as a possible threat to some of world agriculture, I argue that there is an obligation to stabilize climate. Seen from this point of view the role of economic analysis is to be concerned with discovering the most cost effective means of reaching the goal of having GHG emissions and sinks in rough equilibrium. A. Tractable Morality. There is no obligation to maximize utility or preference satisfaction or anything in that family of ideas. We have a much more tractable account of our moral obligations. Rather, we can follow Locke in stating our obligations in terms of the preservation of persons: understanding this to mean preserving their lives from external threats, preserving and enhancing their moral and religious choices, and assuring the means to subsistence. In the trustee conception the fundamental job of the nation states is not to create opulence or to correct for market failures--but to preserve the persons of their citizens				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			now and in the future. An element in this overall obligation is to keep the various kinds of goods discussed above in proper balance. Other Problems. This chapter also fails to draw on the large literature on intergenerational justice. An excellent compendium by Bayard Catron entitled Ethical Dimensions of Environmental Policy and Decision Making: Risk Management, Intergenerational Equity, and Discounting(Washington, D.C.: NAPA, 1993) would have helped a lot. Beyond this the authors seems unaware of the literature on the nature and unpredictability of ecological change. See, for instance, C.S. Hollings, "A Cross-Scale Morphology, Geometry, and Dynamics of Ecosystems in Ecological Monographs 62(4) 1992, pp. 447-502, esp. pp. 478-485 for a discussion of the inherent unpredictability of the future. 4. Social welfare functions are generally assumed to be an summary of the preferences revealed by a political process, and are used as a convenience in theoretical explorations of the necessary conditions for maximizing some concept of social welfare in which both efficiency and equity matter. When a policy that satisfies the efficiency conditions results in a redistribution of income that is judged to be undesirable (based on some idea of a social welfare function) the consensus approach is to design compensatory programs or transfers that make it possible to achieve both efficiency and equity. This is the Birdsall and Steer recommendation. The "prescriptive" approach abandons any efforts to reconcile efficiency and equity, and recommends policies that leave all generations worse off compared to the welfare they could achieve if efficient climate policies were adopted and intergenerational transfers dealt with through policies affecting savings and investment. Birdsall, N. and Steer, A. Act Now on Global Warming - But Don't Cook the Books, Finance and Development 30 (1), pp. 6-8. 5. The discussion of the chapter on the problem of earmarking revenues for future generations in a Fund for Greenhouse Victims (Page 16, lines 33-35) is both erroneous and irrelevant if the possibility of providing for future generations through capital investment is admitted (Stiglitz). Today's investment in physical capital increases future productive capacity; no other funding is required to make future generations better off. Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982.				

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			6. I have a serious interest in this issue, and found Chapter 4 to be helpful to my own thinking. However, I feel the chapter overstates the merits of the prescriptive approach relative to the merits of the descriptive approach. My comments below elaborate on this point, and suggest some textual changes that would help to redress the balance. The primary criticism leveled at the descriptive approach is that there is no guarantee that investments we make now will ultimately benefit individuals in future generations who may be harmed by climate change. However, this exaggerates the difficulties of transferring non-environmental capital to those harmed by climate change, and it fails to recognize the difficulties inherent in transferring environmental capital. Barring an event like the "dark ages," investments which expand the stock of technological knowledge cannot easily be squandered by future generations. Moreover, since the benefits of advancing technology are significantly a public good, it is not plausible that these benefits will somehow fail to help the particular individuals in future generations who may be most harmed by climate change. Likewise, investments in education, particularly of women, seem to produce self-sustaining social change which lowers population pressure, and this too has spillover benefits to all members of future generations. Thus some very important classes of non-environmental investments are likely to have enduring payoffs in future generations, and those payoffs are likely to be available to those who are ultimately harmed by climate change. Moreover, it should be acknowledged that environmental investments we make to reduce CO2 emissions can be subverted in the future, as long as oil, gas, and coal resources remain available to be used at some future date. Thus today's investment in CO2 emissions reduction may be equally or more at risk of being squandered or "misappropriated" than investment in other kinds of non-environmental capital, particularly education and research. 7. As Chapter 4 acknowledges, the prescriptive approach is fundamentally an ethical position, shared (more or less) by many social scientists who are highly educated and wealthy, at least relative to the people likely to bear the cost of controlling CO2. If the observed income redistribution policies of the world's governments are grossly inconsistent with the ethical norms of these individuals, it seems to me that the common sense explanation is that most of humanity does not share these ethical norms. The chapter acknowledges that this is possible, but the point is "soft-pedaled," particularly in the summary section where it is not mentioned (even though the critique of the descriptive approach is prominently featured there.)			

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			According to Aaron et al. (1994), these values are affected by affluence. Our future generations, if wealthier and better educated, can be expected to place more value on "respecting and preserving nature and the natural." Will this be handled in the estimates of avoided damages? Aaron, H.J., Mann, T.E., and Taylor, T (eds), 1994, Values and Public Policy, The Brookings Institution. 8. It seems to me much more work needs to be done on telling the modelers how to design their models so as to answer the questions that are imbedded in the discount rate issue. To the extent that the present is transferring substantial resources to the future, we ought to be able to tell people how much. To the extent that under reasonable assumptions per capita consumption will be greater in the future, again, we should know much greater. In other words we shouldn't bury major ethical decisions in the discount rate. In part, this is a result of the lack of connection between Chapter 3 and 4. If the authors want to set aside the major ethical issues then they should explain how decision rules from Chapter 3 will interact with the approaches in Chapter 4. 9. One reason for this is that the preferences of today as expressed by democratic governments, as Chapter 4 notes, differs drastically from the consensus of economists as moral philosophers. We need to give the democratically elected decision makers the information needed to make these decisions, not bury the decision in the choice of a discount rate which reflects our moral judgments which are not those of the public. If we don't do this, our work will become more and more irrelevant. II. Economic Efficiency and Discounting 1. The chapter is unbalanced in its presentation of the economic theory relevant to choice of discount rates. It is not the consensus of professional economists that the social discount rate should be based on the kind of ethical judgments used in the "prescriptive approach" to justify a discount rate of 3% or less. What the chapter labels the "descriptive approach" is in fact the mainstream approach to the subject. The chapter should concentrate on the descriptive approach, and give the prescriptive approach only brief mention as a perspective that suggests climate policy should be treated as a special case and based on ethical judgments that have not been embodied in any other economic policy.			

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			2. The chapter fails to provide a justification for choice of a discount rate lower than the before tax return to capital. What Stiglitz, Dreze and Sandmo, Arrow and Kurz and others demonstrate is that when governments cannot use either optimal taxes or make lump-sum intergenerational transfers, the correct discount rate for evaluating public investments may not equal the before-tax return to capital. There are necessary conditions for welfare maximization that must hold among the return to capital, before and after tax rates of return, and the social discount rate. The chapter states correctly (Page 13, Line 2) that with nondistorting taxes and optimal intergenerational transfers, the social discount rate will equal the before tax return to capital. The chapter is incorrect in dismissing this as a special case. These assumptions are the normal starting point for applied welfare economics. The burden of proof should be on those who argue for different assumptions. Moreover, as will be discussed below, alternative assumptions do not lead to any simple characterization of the social discount rate. 3. If existing taxes create significant distortions between the before and after tax returns to investment, a case can be made for choosing a discount rate between the two (as Nordhaus and others suggest) or for converting foregone investment to consumption at the before-tax return to capital. These are necessary conditions for intertemporal efficiency, and hold regardless of the choice of a social welfare function. Choosing the weights to be applied to before- and after-tax rates of return in computing the average requires an explicit analysis of how climate policy affects investment and consumption. The chapter includes no such analysis and therefore has no basis for concluding that the correct discount rate is not the before tax return to capital, as it would be if the costs of climate policy all come from investment. Nordhaus, W. D. Managing the Global Commons: the Economics of Climate Change. MIT Press, 1994. 4. It is only if governments cannot make intergenerational transfers that choosing a social discount rate different from some weighted average of before and after tax rates of return to capital can be desirable (Stiglitz). But this does not justify an analysis that constructs a social rate of discount from ethical principles, as the prescriptive approach recommends. Instead, the correct theoretical approach (Stiglitz, Arrow and Kurz) is to model explicitly the constraints presumed to exist on intergenerational transfers, the characteristics of the investment in question, and the relation between climate policy, consumption and investment. As Stiglitz shows, the conclusions that follow about the relation between the social rate of discount and returns to capital (before or after tax) will depend on all these factors, and the social rate of discount may be higher or lower than the before tax return to capital. The conclusions that the chapter reaches on the				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			range of discount rates is not based on any such analysis, and therefore has no foundation. Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982. Arrow, K. J. and M. Kurz. Public Investment, the Rate of Return and Optimum Fiscal Policy. Johns Hopkins University Press, 1970. 5. All of the theory of social discount rates assumes that governments attempt to maximize a social welfare function, but face constraints on tax and transfer policy that make it necessary to choose a social discount rate different from the private return to capital. None of the economic theory of discount rates is based on the assumption that governments are maximizing the wrong social welfare function. This is the assumption on which the prescriptive approach adopts (Page 12, line 32). The prescriptive approach posits a social welfare function different from that which governments are assumed to be maximizing in making economic policy, and then uses it to argue for a low discount rate for climate policies. That entire line of reasoning is illegitimate, and certainly does not represent the consensus view of mainstream economists. 6. The "descriptive" approach, which assumes that the preferences revealed by current policies reflect the social welfare function of the nation in question, is the mainstream approach and should be presented as such. The complexities involved in choosing a discount rate for public investment with constraints on tax policy and distribution can then be discussed in that context. 7. The prescriptive approach is relatively well-explained. However, the descriptive view is not presented very coherently. It points to the relevance of alternative investment opportunities, but does not specify exactly what the discount rate should be. 8. The main area of omission in this chapter is the psychological work on intertemporal choice. This research shows a number of decision biases that may have policy implications. Below is a reference list of some potentially relevant papers. Benzion, U., Rapoport, A., and Yagil, J. (1989). Discount rates inferred from decisions: An experimental study. Management Science, 35, 270-284. Cairns, J.A. (1992). Health, wealth and time preference. Project Appraisal, 7, 31-40. Cropper, M.L., Ayded, S.K., Portney, P.R. (1994). Preferences for life saving				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			programs: How the public discounts time and age. <i>Journal of Risk and Uncertainty</i>, 8, 243-265. Ganiats, T.G. (1994). Discounting in cost-effectiveness research. <i>Medical Decision Making</i>, 14, 298-300. Keeler, E.G. & Cretin, S. (1983). Discounting of life-saving and other non-monetary effects. <i>Management Science</i>, 29, 300-306. Lipscomb, J. (1989). Time preferences for health in cost-effectiveness analysis. <i>Medical Care</i>, 27, s233-s253. Loewenstein, G. (1987). Anticipation and the valuation of delayed consumption. <i>Economic Journal</i>, 97, 666-684. Loewenstein, G. (1988). Frames of mind in intertemporal choice. <i>Management Science</i>, 34, 200-214. Loewenstein, G. & Prelec, D. (1992). Anomalies in intertemporal choice: Evidence and interpretation. <i>Quarterly Journal of Economics</i>, 107, 573-597. Loewenstein, G. & Thaler, R.H. (1989). Anomalies: Intertemporal choice. <i>Journal of Economic Perspectives</i>, 3, 181-193. Olsen, J.A. (1993). On what basis should health be discounted? <i>Journal of Health Economics</i>, 12, 39-53. Prelec, D. & Loewenstein, G. (1991). Decision making over time and under uncertainty: A common approach. <i>Management Science</i>, 37, 770-786. Redelmeier, D.A. & Heller, D.N. (1993). Time preferences in medical decision making and cost-effectiveness analysis. <i>Medical Decision Making</i>, 13, 212-217. Redelmeier, D.A., Heller, D.N., & Weinstein, M.C. (1994). Time preference in medical economics: Science or religion? <i>Medical Decision Making</i>, 14, 301-303. Shelley, M.K. (1993). Outcome signs, question frames, and discount rates. <i>Management Science</i>, 39, 806-815. Shelley, M.K. (1994). Gain/loss asymmetry in risky intertemporal choice. <i>Organizational Behavior and Human Decision Processes</i>, 59, 124-159. Thaler, R.H. (1981). Some empirical evidence on dynamic inconsistency. <i>Economic Letters</i>, 8, 201-207. An important issue to resolve for policy makers: How is it we can seriously challenge decision making for unfamiliar goods and not "choices?" In addition, what do these studies indicate about framing the "time horizon?" 9. This seems to me to be the next step in the process of creating the models and analysis that will help us perform a systematic economic analysis of climate change policies. 10. The chapter exhibits two strong biases of the authors: (1) the "proper" discount				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			rate is the social rate of time preference (SRTP) and (2) the component of the SRTP corresponding to the pure rate of time preference should be set equal to zero. These positions do not represent the consensus of the economics profession and the chapter should be revised to provide greater balance in the treatment of different approaches to discounting. 11. The formulation of the SRTP as the sum of the pure rate of time preference and an adjustment for changes in the marginal utility of consumption due to per capita consumption growth is presented as if this is a general result that is value free. It is described as "the fundamental equation for the discount rate of consumption," (page 6, line 44). This treatment obscures normative assumptions that underlie the derivation of the SRTP. For example, the derivation is dependent upon acceptance of assumptions about "welfarism," (the concept that social welfare is a function of only the welfare of individuals), the comparability of welfare across individuals, and a specific class of social welfare functions. The underlying social welfare function assumes that social welfare in time t is reducible to per capita consumption in time t and is independent of the distribution of consumption among individuals in time t. Individuals living in different periods enter the social welfare function identically with the exception of a discount factor for pure time preference that varies as a function of distance from the present. These normative assumptions yield a SRTP that varies with per capita consumption growth, adjusted by the marginal utility of consumption, but not, for example, changes in the variation of consumption across individuals. The assumptions may be reasonable approaches to simplifying the problem intertemporal optimization and discussion of them may not be necessary when writing for professional economists. But the audience of the WGIII report will include non-economists. For these readers, it is important to make the normative underpinnings of the SRTP explicit and discuss what they imply about intergenerational and intragenerational equity. 12. This chapter has improved over earlier versions, but still could use some work. One general suggestion would be to have the chapter consider efficiency on a level more comparable to the current emphasis on equity. For example, shouldn't efficiency be in the chapter title and receive more attention in the summary? Also, there could be some additional explicit discussion of what efficiency means in the intergenerational context; the standard view that efficiency is a less controversial criterion than equity				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			has some merit for this application. III. Implications for Policy Analysis 1. I believe that the Chapter is an excellent survey of the issues and literature on discounting and intergenerational equity. It falls short of giving the modelers who are trying to evaluate alternative policies any specific guidance. I suggest an approach to this shortcoming. I also feel too little has been said about sequential analysis of options and particularly the option of waiting. 2. However, if I were one of the two or three dozen researchers developing integrated assessment models, I probably would feel let down that I wasn't told which rate I should use in my model, or more importantly, how I might modify my model or use it to answer the questions regarding efficiency and intergenerational equity that are addressed in Chapter 4. 3. Let me suggest an approach, although time and space preclude a complete analysis of this issue which should be the next project for research on discounting and global climate change. I believe the key to the answer lies on the discussion on pp. 13-14. There are two key rates: (1) the rate at which we discount consumption and (2) the marginal rate of return on investments that are alternatives to investments in climate change abatement. I suggest that we keep these two rates separate in our models for the purpose of clarity. For example, in integrated models that explicitly model economic growth, one would use the rate of return on alternative investment in determining the growth path and consumption path if the proposed investment in climate change were instead invested in the economy. Consumption over time would then be discounted to its present value using a rate reflecting the SRTP. This would then become the baseline against which global climate policies would be compared. This seems to be what the chapter is suggesting, but it is somewhat hidden by all the other arguments. 4. This approach is very similar to the shadow price of capital approach, however, by disaggregating the analysis, it forces us to specify and debate what the alternatives to investment in climate control are and what rates of return could be earned. It forces us to look at consumption rather than GNP. We can debate and vary the SRTP of discount separately. In short, it helps us keep straight the myriad of issues that are involved and doesn't bury them in a single discount rate. For example, Cline gets a discount rate of 2% - 3% (p. 14) by assuming that 80% of				

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			cost comes at the expense of consumption and 20% at the expense of investment. Such an assumption might have followed from the assumption that the money was raised by taxation and the marginal propensity to consume was .8. The problem with this analysis is that the government could have invested it in other public projects. The problem with most second-best lines of analysis is that we don't properly account for the opportunity cost and the approach suggested above would force us to do that. 5. Finally, we need to look more carefully at sequential approaches to this problem. The sequence we should follow is not necessarily act, learn, act. The optimal sequence, given the uncertainty we act may be to wait, learn, wait, learn, maybe act. Given the feasible size of budgets that will be devoted to this problem, gathering information and developing the technologies for the future may be our best option. 6. Economists know something about how individuals and companies trade off current and future cash or consumption. We know much less about how people trade off their consumption for the consumption of their descendants -- or don't like the answer we observe in such behaviors as national finances. We have even less to say about how people trade off their consumption relative to the consumption of future generations in other countries -- or don't like the answer at all, as demonstrated by the abhorrence of the American electorate for foreign aid. Can this meaningfully be expressed as a discounting problem at all? Schelling's argument that after a certain point future generations run together has some real common sense to it. Furthermore, much of the benefit that takes place far in the future cannot reasonably be estimated anyway, because it involves health and eco-system effects which are not well-defined and whose valuation is uncertain and controversial. This suggests that a multi-criteria approach to the problem is more suitable. However, this risks painting the problem as one of fundamental values of current generations about their stewardship responsibility over the planet and its future inhabitants, and thus losing the sense that these are small benefits far in the future. 7. These are topics of greater than average difficulty. Consideration should be given to organizing the chapter along the following lines: - Economics provides no clear answers to many of the issues raised by discounting in this situation. There are strongly held opinions on all sides of the question. - The use of multi-criteria analysis provides an alternative to trying to discount the future benefits of current climate change mitigation strategies, although multi-criteria analysis is not without its own drawbacks.			

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			- There is a strong philosophical following for the use of low social discount rates for discounting future consumption, and a strong practical following for the use of rates nearer market levels. Trying to value the effects of foregone investment on future consumption is complex and possibly subject to manipulation. It is hard to justify lower discount rates for this particular type of social investment than for the many other types of investment that are currently made. Faced with this dilemma, some analysts have chosen compromise rates between these positions. An alternative is the use of multiple discount rates by analysts. The implications of this approach, with all results provided to other analysts and policy makers, might usefully be addressed in this chapter. 8. Firms and Planets. The authors conflate the use of a perfectly usable framework about decisions within a firm or public agency with a program of planetary management. We need to distinguish between the means to achieve efficiency through markets or their surrogates, and the things that make markets possible--their preconditions. In "The Cultural Contradictions of Capitalism" Daniel Bell argues convincingly, to me at least, that capitalism depends on certain virtues (e.g. thrift, hard work etc.) that it tends to erode. Surely the earth's basic systems such as climate are candidates for being among market preconditions, and are being disequilibrated by unconstrained markets. 9. GNP a Mismeasure of Man. The problems with the GNP (p. 21) measure are far more extensive than even the literature on its defects (e.g., corrections for capital depletion, defensive expenditures and the like) recognizes. None of these revisions deals with the underlying problem that it embodies far too narrow a conception of human well-being to begin with, because it focuses too much on consumption. A much more promising way of thinking is being developed by Nussbaum and Sen entitled the capability approach. see, for instance, The Quality of Life. They argue that there a generic set of capabilities that define the good life, and that consumption is instrumental to only some of them. This grounds Sen's claim that development as normally understood is a result of conceptual and moral failures. IV. Editing and Clarification All but one of these points are noted in the specific comments on the chapter. 1. My comments will likely point out which parts of this chapter are unclear to a				

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country	#)		
			non-economist. This chapter sometimes provided clear explanations of relevant concepts and other times used cryptic economics shorthand that I was not able to follow				
1	1	14	Why is the alternative chapter posited? If efficiency is an important consideration in discounting - and surely it is - then it should be mentioned in the actual title and should get adequate treatment in the chapter.	USA	32	G	
1	2	24-26	Agreement on this is not widespread.	NED	09	G	
1	2	33-34	Literature on the growth of green GNP (Repetto, Hueting) sometimes comes up with growth rates over the past decades of -0.5 to -3%.	NED	09	G	
1	2	10-11	The choice of words "collapse of future" could have a wide range of interpretation depending upon a readers frame of reference. Suggest text read instead: Such results make clear how difficult it is to draw quantitive conclusions from calculations based on such long time horizons.	IPIECA	18	A	
1	2	7-11	The reviewers find that the example given here is very effective in driving home the importance of discount rates in the context of climate change. We would encourage the use of more examples of this type in this chapter.	CAN	24	G	
1	2	11	The flip side of the collapse of future values due to discounting is that very small displaced investments can lead to very large future shortfalls in output.	USA	32	G	
1	2	28-34	This generalized egalitarianism seems to have to do with transferring wealth from the rich to the poor (utilitarianism) and seems logically unrelated to intertemporal or intergenerational trade-offs. It just so happens that future generations are expected to be wealthier than the present generation. Does'nt this assumption need to be considered in constructing our scenarios of the future?	USA	32	G	
1	2	38	The implication that markets do not effectively allocate goods over time (and particularly over generations) is controversial. It affects more than global warming policy and raises significant questions about national savings policy and use of exhaustible resources. Do not believe there is a consensus among economists that market interest rates are generally incorrect guides to behaviours in those settings.	USA	32	G	
1	2	40-44	How, exactly, are intergenerational trade-offs for environmental goods different from those for private consumption goods? Converting environmental goods to their	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			equivalent in private consumption goods would seem to ensure that these two types of trade off are treated equivalently, not differently.				
1	3	9-11	The reviewers agree with this point.	CAN	24	G	
1	3	8	What is the "incremental component" of the discount rate? Is this the idea that risks compound over time? If so, why would we not want this aspect incorporated into the discount rate?	USA	32	G	
1	3	13	How can certainty equivalents be used to treat issues of equity?	USA	32	G	
2	3	42	It is argued that most countries pass the weak sustainability criteria. Believes that this conclusion is based on Pearce's compilation of estimates a couple of years ago. These estimates are highly uncertain, inherently complex and difficult.	SWED	17	G	
2	3	35	The sustainability school of thought as outlined by: Pearce, D.W. and R.K. Turner (1990), Economics of Natural Resources and the Environment, Harvester Wheatsheaf, London, is an important published school of thought in respect of intergenerational equity and could be added to the text. Add: The extent to which natural and cultural resources are substitutable is critical to this analysis and is highly contentious. Many economists including Pearce and Turner (1990) stress the need for sustainability limits to guide natural resource use which will be needed by, but cannot be created by, future generations.	AUST	23	G	
2	3	37-41	Good point.	CAN	24	G	
2	3	21	The compensation problem deserves some discussion, it is relevant for any discount rate.	USA	32	G	
2	3	33	Why "must" discussions of intergenerational equity go beyond sustainability? Brown-Weiss, for example, implies that sustainability is a "legal" (though perhaps more accurately, "a plausible ethical") obligation that generations face. What evidence is there of a consensus that governments should be allowed to make poorer generations suffer so long as richer generations gain sufficiently? Arguably this view is controversial, yet it is implicit in the utilitarian framework that drives the equity analysis of this chapter. While this framework is important and merits exploring, it should be made clear that this is not the only possible framework. It should also be explained to policy makers that despite the technical content of this discussion, the material covered is quite normative, and that while economists have expertise in	USA	32	G	

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			analyzing these norms, they are not in a position to determine them for society.				
2	4	14	According to Chapter 3, Rawls is a utilitarian.	NED	09	G	
2	4	0	It should be noted that Rawls himself argues that the maximum criterion should not be applied to intergenerational problems (Rawls 1991).	SWED	17	G	
2	4	10-19	Contrast between utilitarianism and min-max is well summarized.	USA	32	G	
2	4	21-35	Re. Schelling's dissenting opinion. Distributional considerations can be incorporated into utilitarianism. Distributions affect individual utility by way of perceptions of fairness and emotions such as envy. (see also p. 5, lines 9-18).	USA	32	G	
2	4	0	Re. Box. The discussion of Schelling's view is too abstract to be useful to policy makers. Regarding the conclusion in the Box, it is not obvious that the analyses presented in the chapter-- which, in effect, suggests consumption transfers across generations to help equate marginal utility -- is appropriate in a world where richer nations make only modest transfers to poorer ones.	USA	32	G	
2	5	12	The sentence on Thurow's paper should probably be moved to later in the para.	USA	32	G	
2	5	20-26	If environmental outcomes are not discounted, but other outcomes (eg, financial ones) are, certain inconsistencies will result such as preference reversals (see Keeler and Cretin, 1983). This is certainly a consequence of "special treatment" that should be pointed out to policy makers.	USA	32	G	
3	0	0	The following comments are applicable to Chap. 4, sections 3.3.1 and 3.7, chap. 6, sections 6.1.2 and 6.1.3, and p. 7 of the PMS. The use of discount rates assume that investment is made at time "t" and the yield would come sometime in the future. It applies to marketable goods and services. The choice of discount rates may be extremely difficult in addressing environmental goods and services. This is true, particularly, to non-marketable goods and services. Non-marketable goods and services may represent secondary, tertiary, etc., indirect or derived costs and benefits of economic activities. In fact, ecologists have argued that that the environmental value of non-marketable goods and services may represent the largest portion of environmental damages, more so of their cumulative effects. It is	CAN	24	G	

Reference Section	Page	Line	Comments	Reviewer (Country #)	ID	Response
			suggested in the report that the relative prices of environmental services is unlikely to rise and thus the effective discount rate can be lower than discount rates used for goods (marketable?). This is particularly troubling issue. Considering the fact that there are limited information on ecological effects of GHGs, and the need to account (value) for non-marketable goods and services, the assumption of declining/constant price or discount rates is questionable.			
3	5	30	The discussion in the prior section is also prescriptive.	USA	32	G
3	5	37-44	See comment re line 30. Would not the answer to these three questions be the same, because of the inconsistencies that result from using different discount rates for different outcomes?	USA	32	G
3	6	0	The five points put forward here are clearly stated and well argued.	USA	32	G
3	6	7-10	Why is this argument limited to benefits accruing to the same generation? The whole idea of utilitarianism is that utility can be traded off across people.	USA	32	G
3	6	38	Should add the following sentence to this para.: "However, given appropriate estimates of relative prices, there is no reason to explicitly modify the discount rate."	USA	32	G
3	7	0	The reviewer has doubts on whether the formula is correct. Seems to be too simple. It presumes that welfare is so well-defined that one could take the first derivative to consumption. This is doubtful at least, as it is doubtful that, could it be done, "v" would be a constant as is suggested. But if it could be done, why would one be happy with the first order Taylor approximation? Global change is hardly a local problem.	NED	09	G
3	7	20-24	"If the project displaces private investment that has a high marginal productivity...The prescriptive view takes into account opportunity costs in calculating changes in consumption, but in valuing the changes in consumption, uses the SRTP." It appears that what is being said is that, where mitigation projects displace other investments, future consumption must be reduced by the consumption that the displaced investment projects would have generated. It is net consumption that is to be discounted with the social rate of time preference. This appears to be a compromise between using low social discount rates throughout the analysis and using the opportunity cost of capital throughout the analysis. It is not clear however, what one does in practice. The suggested discounting method is both confusing and subject to manipulation. Specific examples are required to aid clarification.	IPIECA	18	A

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
3	7	3	The social welfare function and related relationships used to derive this equation should be stated explicitly. It is the most important equation in the chapter but has not clearly been derived for readers. A reference to the annex and a full presentation there would be useful.	USA	32	G	
3	7	8-14	Throughout the chapter it is unclear about the relationship between the SRTP and the market interest rate. Is SRTP meant to express discounting above and beyond discounting because of investment opportunities? Investment opportunities (leading to a particular market interest rate) presumably exist because of economic growth, g. So why is g so much smaller than current interest rates? (see also p. 12, line 38 to page 13, line 8.)	USA	32	G	
3	7	20-24	"If the project displaces private investment that has a high marginal productivity... The prescriptive view takes into account opportunity costs in calculating changes in consumption, but in valuing the changes in consumption, uses the SRTP." Believe what is being said here is that, where mitigation projects displace other investment, future consumption must be reduced by the consumption that the displaced investment projects would have generated. It is net consumption that is to be discounted with the SRTP. This appears to be a compromise between using low social discount rates throughout the analysis and using the opportunity cost of capital throughout the analysis. However it is not clear what one does in practice, and am concerned that the discounting method suggested will be both confusing and subject to manipulation. Any investment can be argued to displace some other investment that would generate (at least) the opportunity cost of capital. And that investment will yield returns, some of which will be re-invested. The suggested procedure may be better in concept than in practice. If this procedure is to be proposed, specific examples are required for clarification.	USA	32	G	
3	7	44	This is the only reference to Loewenstein and others on decision biases in intertemporal choice. In addition to the common difference effect cited here (lower discount rates for longer delays), descriptively, discount rates are lower for large magnitudes, for losses compared to gains, and for sequences out outcomes, compared to individual outcomes. Finally, temporal discount rates expressed in decision-making experiments are typically 50% annually or more, much higher than those discussed in this chapter. What implications to these findings have for potential climate change policies and the success of their implementation? One implication might be that because many people have personal discount rates much higher than those suggested in this chapter, they would be uncooperative with the resulting policies. Am not familiar	USA	32	G	

Reference			Comments	Reviewer (Country #)		ID	Response
Section	Page	Line					
			with psychological work looking at intergenerational decisions however (but see Lipscomb, 1989).				
3	8	0	As stated elsewhere in this chapter, shouldn't risks, such as the small change of human extinction, be incorporated into a certainty equivalent, which would then be discounted?	USA	32	G	
3	9	19	The finding that the optimization problem is not well defined should be further elaborated.	USA	32	G	
3	9	24-35	It is not clear why these knife-edge results occur.	USA	32	G	
3	10	9	Do not share the opinion that it be viewed as a "problem" with utilitarianism. The normative status of utilitarianism is independent of descriptive behaviour(such as the unwillingness of people to make large sacrifices to benefit future generations.)	USA	32	G	
3	10	38-41	This is biased. If one discounts outcomes from generation 1 to generation 2 much more than for generation 101 to generation 102, one is not exhibiting constant discounting. Although someone in generation 1 may view a benefit delivered to generation 101 as equivalent to the same benefit to generation 102, someone in generation 101 would not have the same view. This illustrates the preference reversals that result from non-constant discounting. The comment about the empathetic distance suggests the need to clarify how the discounting is grounded in a particular time period. Also, other social science research shows that there are markedly different cultural views on concepts of time that affect behaviour.	USA	32	G	
3	11	22	Insert "absolute value of" before "elasticity".	USA	32	G	
3	11	26	Are the low rates of productivity a US phenomenon or applicable to the world?	USA	32	G	
3	11	38	See this reviewers comment for p. 11, line 22.	USA	32	G	
3	12	11-12	This statement does not seem right. A very high theta (say 50) would imply that one requires an incredibly high rise in the next generation's per capita consumption before one would agree to a small decrease in one's own generations's consumption - not very equitable. Instead higher values of theta seem to imply more selfishness, lower values imply altruism, and some intermediate values imply equity.	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
3	12	11	What is meant by "The more weightequity." there are all kinds of equity criteria, each with different values of Q. One view of equity would be very protective of worse off generations; another might be less so.	USA	32	G	
3	12	27	While there are a number of equity reasons to intervene to help the very poor, the idea that government should fine tune the income distribution is less clear. At some point government intervention can cause inefficiencies and can run into other equity problems such as those associated with confiscation.	USA	32	G	
3	12	40	Should "even" be "particularly"?	USA	32	G	
3	13	12-17	Where do these specific discount rates come from?	USA	32	G	
3	31	0	Needs further elaboration.	NED	09	G	
4	14	13	Should'nt one state that based on "certain" ethical grounds, it is tough to support the higher time preference rate?	USA	32	G	
4	14	15	What is OECD?	USA	32	G	
4	15	30	Replace "most plausible discount rates" with "discount rates below 10 per cent". The presentation of the example does not follow the methods advocated by the chapter. The authors should carefully constuct an example that demonstrates the various discounting approaches discussed in the chapter, including all their steps.	USA	32	G	
4	15-16	0	The meaning of "institutionally infeasible" is not apparent as cited in reference to option d. An explanation needs to be provided.(p. 15) Re. p. 16, lines 43-44. The prescriptionists response for using low discount rates seems rather weak as presented here. Are there any other arguments that would make their position more credible?	IPIECA	18	A	
4	16	9	The estimate of a 15.1% real return to non-residential capital over the period 1975-90 seems very high. The estimates should be properly attributed to their respective authors.	USA	32	G	
4	16	33	Would'nt general economic growth address a large share of the damages from	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
			warming? Moreover, compensation of future parties that lose from particular policy choices is difficult regardless of the discount rate chosen.				
4	16	33-35	Replace the last two sentences with the following: "Society may not be willing to make other investments, for example in education and research, which could reasonably be expected to benefit those adversely affected by climate change, even hundreds of years in the future. Even if society were willing to make such investments, there is no guarantee that their rate of return would remain where it is today over this entire time period."	USA	32	G	
5	0	0	The conclusion that it is not appropriate to discount for risk or uncertainties is correct.	SWED	17	G	
5	17	1	The existence of multiple market failures is a classic problem of the second best. It is not obvious whether piecemeal fixes would make things better or worse.	USA	32	G	
5	17	19	Footnote 3 is unclear. Risk aversion (declining marginal utility) is supported by data, for example. Agree that it is not clear what the authors are saying about data. Also, what about the data that shows risk loving over losses? Is GCC a problem of losses or gains? Footnote 2 is also unclear. Does "G" refer to the public good? If so, it is not defined until 7 pages after the endnote shows up.	USA	32	G	
6	18	17	If there is no intertemporal welfare maximization by the government, then how can one assert that market rates are necessarily wrong? Couldn't the lack of intervention be viewed as an endorsement of market rates?	USA	32	G	
6	18	21-30	It is unclear from the text just what a shadow price is.	USA	32	G	
6	18	29	The work presented by Lyon at the IPCC meetings show that a shadow price of capital of 1.5 to 2 may be quite low, given the rates of time preference assumed by Cline and others. For example, with no reinvestment of capital income(except for coverage of depreciation), a rate of time preference of 2%, and a return to capital of 8%, the SPC will be 4.0. If 10% of net returns to capital are reinvested, the SPC rises to 6; and if 20% of net returns are reinvested, the SPC rises to 16. Moreover, if the rate of time preference is 1.5% - as is argued several times in this chapter - then the SPC under the last set of assumptions would be infinite. (Note that the total weight on costs will be below these values, as only the portion of costs coming from investment gets weighted by the SPC).	USA	32	G	

Reference			Comments	Reviewer		ID	Response
Section	Page	Line		(Country #)			
6	19	1	The relationship of the discussion in this Para. to the shadow price of capital approach is unclear.	USA	32	G	
8	21	5- 6	The statement that most evidence from economic history suggests the possibilities for economic substitution is high could be misleading. First of all, there are a number of cases from econmic history which point in the opposite direction. eg. the rapid protection of the ozone layer, the conflicts over water scarcity etc. secondly, it does create the impression that "no single resource is indispensable" but it is obvious that there might exist several essential functions of nature which life can not be without and which we can not compensate for. Thus the burden of proof lies on those those who claim that substitutability is possible in all cases since they put the rest of humanity in jeopardy.	SWED	17	G	
9.1	23	24	This derivation of the discount rate needs further elaboration. Equation 4A.1 should be maximized, and the relationship of the interest rate to this equation should be explained.	USA	32	G	
9.1	24	4	Again, intergenerational equity can be far more complex than determination of Q.	USA	32	G	
9.1	25	20	Again, the discount rate would not be negative if prices are appropriately adjusted. See this reviewers comments on p. 6, line 38 of this chapter.	USA	32	G	
9.1	25	23	The relationship of the Sandmo-Dreze approach to the SPC approach is unclear.	USA	32	G	
9.1	26	7-11	The point being made here is not very clear.	CAN	24	G	
9.2	27	17	Should the statement refer to G=U or G not equal to U?	USA	32	G	