Meeting the Challenge of Global Warming
Reply to Manne and Mendelsohn

William R. Cline[1]
May, 2004

Alan Manne (2004) and Robert Mendelsohn (2004) have vigorously pursued their mandate as "opponents" to my paper on global warming prepared for the Copenhagen Consensus (Cline, 2004).[2] I welcome their critiques as an opportunity for sharpening the debate.

Let me begin with Mendelsohn, whose views are the more diametrically opposed to mine. He raises the following key concept: The world's present carbon emissions are "benign" because currently the world is below optimal temperature, so why not let the future take care of itself and adopt its own abatement when the proper time comes. It should be emphasized that this is a radical position. Virtually all of the other optimal abatement analyses arrive at some degree of abatement even early in the horizon. They typically have a lesser cutback of emissions early and greater cutback later (including in my optimal path), but that results from the effect of discounting for rising utility and (in some cases) falling abatement cost as technological alternatives widen. None is premised on the notion that current emissions do not contribute at all to future damages because they are benign.

Set aside for the moment whether the optimal amount of global warming would be 2.5°C, which Mendelsohn appears to believe. Consider simply the following problem. Even if we wished to set the world's thermostat at 2.5°C above the pre-industrial level, it would be inadvisable to do nothing now and leave action to the future. The reason is that warming cannot be stopped on a dime. There is a 30 year or longer ocean thermal lag from emissions to warming. There are also decades-long lags from construction of power plants and other carbon-using capital stock today to the date when it is time to replace them.

Table 1 shows what Mendelsohn's "Let the Future Take Care of Itself" (LFTCI) strategy would imply. Using the DICE99CL model (see Cline, 2004), and even allowing for the tiny carbon tax proposed as optimal by Mendelsohn, baseline emissions would rise to 14 billion tons of carbon (GtC) by 2045.[3] By then the future would have arrived: the world would have to stop emissions in their tracks by cutting them back to less than 3 GtC annually in order to hold global warming by 30 years later at close to 2.5°C. While we could enjoy deminimus abatement costs for the next four decades, suddenly in the fifth decade and after abatement costs would surge to about 5 percent of world product in order to keep warming from going beyond Mendelsohn's benign limit.

---

[1] The author is Senior Fellow, Center for Global Development and Institute for International Economics.
[2] The three papers are available at www.copenhagenconsensus.com.
[3] The DICE99CL model adapts the DICE99 model of Nordhaus and Boyer (2000).

We know from costly experience that political processes make it difficult to implement such sudden and wrenching policy changes. The fundamental problem with Mendelsohn's approach is that it fails to set the world on a path toward feasible limitation of warming to within the limit he considers benign (which itself involves a debatable tolerance of much more warming than in the past most in the scientific community would have considered safe). Even if somehow the path of emissions could be halted abruptly, there would be intergenerational inequity involved. The path in table 1 implies allowing global industrial emissions to rise from 1.2 tons of carbon per capita (tcpc) today to 1.5 tcpc by 2045, only to be followed by an abrupt reduction to 0.2 tcpc by 2055.

Table 1

Implied Policy under Mendelsohn't LFTCI Strategy*

	Emissions (GtC)	Cut from baseline %	Abatement cost %GWP	Warming oC
2005	8.59	0.45	0.01	0.69
2015	10.03	1.05	0.03	0.99
2025	11.41	1.48	0.04	1.28
2035	12.76	1.80	0.06	1.57
2045	14.11	2.04	0.07	1.84
2055	2.51	87.40	3.74	2.12
2065	2.60	87.50	4.04	2.38
2075	2.66	87.83	4.34	2.51
2085	2.68	88.35	4.65	2.58
2095	2.67	88.99	4.95	2.64
2105	2.77	89.09	5.26	2.69
2155	4.11	87.04	4.98	2.74
2205	7.34	81.96	4.38	2.91

*Let the Future Take Care of Itself

Mendelsohn calculates his own optimal abatement path. It involves setting an initial carbon tax of $1 per ton, raising it to $10 per ton by 2050, and to $20 by 2100. When this path of carbon taxes is applied to the DICE99CL model, it generates truly negligible reduction in warming. As shown in table 2, the resulting reduction from baseline warming amounts to less than 3 one-hundredths of a degree Celsius by 2100, and less than one-tenth of a degree by 2300 (extrapolating his straight-line tax path). It is highly misleading to use the phrase "optimal abatement" in describing such a path. "Optimal inaction" would be far more transparent, and indeed much more in keeping with Mendelsohn's diagnosis of the problem.

Table 1

Mendelsohn's Implied Optimal Warming (degrees Celsius)

	Baseline Warming oC	Carbon tax $/tce	Emissions cut from baseline (%)	Optimal warming oC	Abatement impact oC
2005	0.687	1	0.45	0.687	0.000
2015	0.988	3	1.05	0.987	0.000
2055	2.124	11	2.22	2.116	-0.008
2105	3.464	21	2.60	3.436	-0.028
2155	4.576	31	3.06	4.530	-0.046
2205	5.563	41	3.29	5.500	-0.063
2255	6.504	51	4.09	6.426	-0.078
2305	7.413	61	4.92	7.316	-0.098

Baseline, % cut, and abatement impact: calculated using DICE99CL. (Cline, 2004)
Carbon tax: Mendelsohn (2004).

Mendelsohn makes much of the argument that recent literature has downscaled the likely damages from global warming. He states incorrectly that my empirical estimates "rely on studies that are over 10 years old." Instead, the climate damage function I use for the empirical estimates is from the DICE99 model of Nordhaus and Boyer (2000). They explicitly cite Mendelsohn and Newmann (1999), calling it "the most optimistic outlook of the recent research (p. 70)," so their chosen damage function should already have incorporated the benefit of Mendelsohn's advice about relatively recent findings. The Nordhaus-Boyer estimates already take account of a substantial reduction in damage estimates from the early levels for traditional effects in agriculture and elsewhere, because of adaptation opportunities. Nordhaus and Boyer introduce a component for willingness to pay to avert the risk of thermohaline circulation or other disaster, however. Mendelsohn for some reason is prepared to simply dismiss this component of damage. Surely this is assuming away what is potentially the most important part of climate damage.

Nordhaus and Boyer do allow for an initial zone of favorable rather than unfavorable effects of warming. Using the DICE99CL model, effects are favorable until cumulative warming (above 1900) reaches 1.28°C, which occurs by 2025. Further warming then begins to cause net damages. The Nordhaus-Boyer limit for benign warming, then, is only half the amount proposed by Mendelsohn. In the DICE99CL baseline, warming reaches 2.5°C by 2070, and the Nordhaus-Boyer damage function places the adverse impact for this amount of warming at 1.1 percent of world product, compared with Mendelsohn's zero net effect.

With respect to changes in the more recent literature, in my view the most important recent scientific information in this debate is the finding by Andronova and Schlesinger (2001) that the upper bound for benchmark $2xCO_2$ is not 4.5°C but 9.3°C at the 95 percent confidence level. Mendelsohn is aware of this new evidence (we were both at a recent conference where it featured prominently; Cato, 2003) but for some

reason chooses to ignore it when making his case that the recent research should make us less rather than more concerned about global warming than we were a decade ago.

Mendelsohn also attacks my discounting methodology as "circular reasoning, not a justification." This caricature may be what underlay the critique in the summary article in the *Economist*.[4] Neither Mendelsohn nor the *Economist* recognizes that I based the discounting method on a major body of economic literature concerned with social cost-benefit analysis.[5] Alan Manne, in contrast, not only recognizes this approach but includes it as one variant in his calculations as the "prescriptive" method, even though he prefers the alternative "descriptive" approach. I do believe that the following logical syllogism is valid: a) the distant future is important; b) discount rates frequently used tend to make the distant future completely unimportant; so c) discount rates frequently used can be highly misleading for analyzing the distant future. My paper appeals to this logic only as introductory and motivational, however, and then turns formally to the existing theoretical literature as the basis for applying the Social Rate of Time Preference approach. I return to the discounting issue below.

Mendelsohn strongly prefers tradable permits to carbon taxes. It is not clear why, because he only cites past practice. It would not make much difference which instrument is used in his optimal policy, because his carbon fee is so small it would have little impact. Even by 2100 his $20 tax-equivalent would amount to only 6 cents on a gallon of gasoline (but a 25 percent tax on coal). A key problem with tradable permits owned by historic producers, however, is that if the optimal carbon tax eventually reaches the range of several hundred dollars per ton of carbon, as in my optimal path, there would be an extreme transfer of wealth to the historic owners of the licenses to emit. It would be far better to use this large incremental rent arising from incremental environmental scarcity for expenditure on other objectives, such as improvements in education and health.

Finally, Mendelsohn himself acknowledges that global warming would impose substantial damages immediately on tropical and subtropical regions. While he is comfortable at "Summing … regional impacts across the globe," it is implausible that the richer countries will make transfers to compensate the poorer tropical countries for their immediate damage, so Mendelsohn's diagnosis of benign warming up to 2.5°C not only excludes catastrophic risk but also is indifferent to differentially adverse impact on poor countries. Fundamentally, however, he and I disagree on which is the greater "trap": doing virtually nothing until it is too late (my concern), or taking "draconian" action too soon (his).

Alan Manne's framework for analysis is much closer to my own, and his differences are more nuanced. Indeed, over a time horizon of several decades his bottom line is not far from my own. His preferred "descriptive optimal" path from his MERGE model cuts global carbon emissions from a baseline of 22.5 GtC in 2100 to 5 GtC. My

[4] "To say that without using such a rate, abatement would be minimal is not a very persuasive reason." *Economist* (April 30, 2004, p. 80).
[5] See Arrow (1966), Feldstein (1970), Arrow and Kurz (1970), and Bradford (1975).

optimal abatement path cuts global emissions from 21.4 GtC in approximately the same year (2095) to 11.2 million, a less dramatic cut than Manne's.

Manne's climate damage function is similar to, and potentially more severe than, that of Nordhaus and Boyer (and hence mine). He places "market" economic damage for 2.5°C warming at 0.25 percent of GDP for rich countries and 0.5 percent of GDP for poor countries. He adds a "willingness to pay" (WTP) for avoiding "non-market" damage associated with 2.5°C, set in his main case at 2 percent of GDP for rich countries and 1 percent for poor countries. This means his global damage is in the vicinity of 2 percent of world product for 2.5°C warming, higher than the Nordhaus-Boyer 1 percent of world product at this benchmark and of course far higher than Mendelsohn's zero net global damage for this warming.

Manne also incorporates cheaper opportunities over time for switching to non-carbon energy, the consequence of a widening technological menu for non-carbon energy than is available in the Nordhaus-Boyer abatement cost function. His optimal path cuts warming from 4.5°C by 2150 in the baseline to 2.5°C ("descriptive") or 1.5°C ("prescriptive"). My optimal results, even with what he would call "prescriptive" discounting, are more pessimistic, cutting warming by 2150 from a baseline 4.5°C to 3.6°C. Manne's optimal carbon tax path (descriptive case) is also in the same order of magnitude as mine. His optimal tax in 2100 is $250 per ton using his lower (2 percent of rich country GDP) valuation of WTP for insurance against non-market damage; and $550 per ton using his higher variant (4 percent for WTP). My optimal carbon tax in 2100 is $560. All of these estimates are radically higher than Mendelsohn's $20 estimate.

So the first point to emphasize is that at least by 2100 or so Manne's results broadly support mine, especially when judged in comparison to Mendelsohn's analysis. In particular, unlike Nordhaus and Boyer, Manne does not accept the idea that previous projections of baseline carbon emissions should be vastly reduced because of new analyses of greater resource limitations and more rapidly rising extraction costs. (Nordhaus and Boyer cut their baseline emissions by almost half from Nordhaus' earlier work, or from 25 GtC in 2100 to 13 GtC).

Manne's bottom line does differ substantially from mine, however, on the question of how early abatement should occur. His optimal carbon tax in 2020 even with the high willingness to pay is only $40 per ton of carbon, whereas my optimal tax by then is $220. This result appears to be driven in part by cheaper carbon reduction costs later in the horizon thanks to technological change, and in part by his use of a higher discount rate.[6] Thus, Manne's "descriptive" optimal cuts from baseline are small until about 2040, then become increasingly deep. The availability of a falling unit-cost abatement function from future technology change is absent in the Excel version of the DICE model (even as adapted to DICE99CL), suggesting that comparable depth of optimal cutbacks might be achievable at considerably lower carbon taxes than in my estimates. When

[6] "Most of the abatement occurs during the period when technology has improved, and abatement becomes less costly." (Manne, 2004, p. 7).

Manne uses "prescriptive" discounting, his optimal cutback timing is much more like mine and in fact the cuts are considerably deeper.[7]

This brings us to the key question of what is somewhat unfairly called "prescriptive" versus "descriptive" discounting. The core issue here is whether there is a zero or non-zero rate of "pure" time preference for impatience. Ironically, whereas Ramsey (1928) called non-zero pure time preference "ethically indefensible," modern users of his optimization framework for saving and consumption regularly apply an impatience rate of 3 percent per year or so, which of course squeezes values over a timescale of centuries down to virtually nothing. The descriptionists invoke observed rates of return on capital as the basis for allowing pure time preference this high. However, the closest empirical measure of pure time preference for the consumer, or the risk-free rate for transferring consumption over time, should be the real treasury bill rate. Treasury bills have no credit risk and no interest rate risk (because of their short maturity). I have reestimated this rate for the United States, and for the period 1949 through 2003 it turns out to be 1.1 percent (calculated from IMF, 2004). If the consumer truly insisted on 3 percent annually just to compensate him or her for impatience (i.e. with no expected rise in consumption level and hence utility), then the US government could not issue treasury bills as cheaply as it historically has done. Importantly, my sensitivity analysis in table 3 of my paper shows that when the rate of pure time preference is raised to 1 percent, the paths of abatement estimated as optimal at zero pure time preference (#1 central case and #3 value-at-risk case) still have a benefit/ cost ratio above unity (although the Kyoto Protocol no longer does).

The real motivation of the descriptionists in using a higher rate of pure time preference is that if zero (or 1 percent) pure time preference is used, a gap arises between the rate of return on capital and the consumer discount rate. But that is the whole point of the social cost-benefit approach: this gap should be taken account of by shadow-pricing a unit of capital as being worth more than a unit of consumption. That is what I do in my method.[8] I would argue that the descriptionists assume away the gap between the consumer's time preference and return on capital by mistakenly imputing a high pure time preference rate, whereas taxes and capital market imperfections are a more plausible explanation for the gap. The descriptionists are actually prescriptionists when it comes to assuming the perfect capital markets and zero tax distortions needed for their formulation of the optimal growth and saving models.

---

[7] In this case his optimal cutback by 2030 is from 10GtC to 4.5 GtC, whereas my optimal cut is from 12.3 GtC to 7.1 GtC. His prescriptive optimal carbon tax in the "immediate future" is $300 per ton, or twice mine. In part this may reflect the fact that his prescriptive specification is that the rate of return (and the SRTP) is only 1 percent, whereas mine is higher (see note 7). Manne's prescriptive run also does not shadow price capital.

[8] It should be pointed out, moreover, that in the initial decades of my baseline, the Social Rate of Time Preference (SRTP) is not as low as the 1.5 percent average over three centuries. Real per capita income rises at an average of 1.4 percent from 1995 to 2015, so with an elasticity of marginal utility of 1.5, and with pure time preference at zero, the SRTP is 2.1 percent.

That still leaves the question of what is special about global warming discounting. First, it is intergenerational. There is a long tradition holding that intergenerational discounting may require a framework from that used for within-generational discounting. Second, I would argue that any problem which has a horizon of three centuries should use the same discounting method I apply. So global warming is only special insofar as it is one of the few areas with this long a time horizon. This method would be even more important to apply in, for example, issues of disposal of atomic waste. Third, however, I have no real problem with applying the Social Rate of Time Preference approach to public policy decisions on time frames of one or two decades, either. If doing so finds that greater amounts of public investment should be taking place than currently occur, the proper response should be to seek greater investment in the other areas as well, rather than to block climate change abatement on grounds that other social expenditures should be undertaken instead. Consideration of the benefit-cost ratios estimated using the SRTP, after properly shadow pricing capital effects, should then place choices among the various areas on an equal footing. Note once again that this does not mean simply "applying a discount rate of 1.5 percent" to judge other areas comparably with the analysis in my paper, because the SRTP will depend on how rapidly per capita income is growing in the relevant (nearer-term) period, and capital effects must be shadow priced.

When it comes to dilemmas for choosing between the environment and today's poor, moreover, it seems to me the debate has missed a key consideration. A carbon tax would raise revenue, and the lack of revenue is a key obstacle to achieving many social goals. Global revenue from my optimal carbon tax of about $200 per ton in 2015, when industrial emissions would be curbed from a baseline amount of 9.2 GtC to 5.4 GtC by the tax, would raise $1.1 trillion.[9] That can buy a lot of schooling and medicine.[10] So rather than coming at the expense of social spending, in practice it is quite possible that carbon abatement could facilitate social spending. Because of revenue realities, action in the climate change part of the Copenhagen Consensus agenda can perhaps more realistically be seen as complementary to, and enabling of, action in the other issue areas, rather than competitive with them.

Returning more specifically to Manne's paper, he suggests that my "Value at Risk" case is an inappropriate basis for policy. I acknowledge that it is included primarily as a warning rather than an immediate call for action as severe as it indicates. Nonetheless, there is something fundamentally disturbing in the fact that society values its money highly enough to take out insurance against the 95-percentile bad outcome in the financial sphere, but is unprepared to do the same when it comes to policies affecting the environment and future generations. At the very least the results for the Value at Risk case should be seen as supporting the extent of action called for in the central optimal-abatement case (#1) by illuminating how much greater warming damages and hence warranted abatement could be in the high-damage tail of the probability distribution.

---

[9] It is often pointed out that environmental taxes are a fragile basis for revenue because if they are successful they suppress the source of their own revenue. The point here is that a large revenue would be generated even after taking account of the reduction in emissions from baseline amounts.

[10] Although the more the revenue is diverted to social spending rather than used to reduce output-distorting taxes, the higher the abatement cost.

References

Andronova, Natalia G., and Michael E. Schlesinger, 2001. "Objective Estimation of the Probability Density Function for Climate Sensitivity," *Journal of Geophysical Research*, vol. 106, no. D19, pp. 22605-12.

Arrow, Kenneth J., 1966. "Discounting and Public Investment Criteria," in A.V. Kneese and S.C. Smith, eds., *Water Research* (Baltimore: Johns Hopkins University Press, pp. 13-32).

Arrow, Kenneth J., and Kurz,Mordechai, 1970. *Public Investment, the Rate of Return and Optimal Fiscal Policy* (Baltimore: Johns Hopkins University Press).

Bradford, David F., 1975. "Constraints on Government Investment Opportunities and the Choice of the Discount Rate," *American Economic Review*, vol. 65, no. 5, December, pp. 887-99.

Cato, 2003. "Global Warming: the State of the Debate," conference held at the Cato Institute, Washington DC, Dec. 3, 2003. Proceedings available at: www.cato.org/events/gw031212.html.

Cline, William R., 2004. "Meeting the Challenge of Global Warming," paper prepared for the Copenhagen Consensus research program. Available at: www.copenhagenconsensus.com.

Feldstein, Martin S., 1970. "Financing in the Evaluation of Public Expenditure," *Discussion Papers* 132 (Cambridge, Mass.: Harvard Institute of Economic Research, August).

IMF, 2004. International Monetary Fund, *International Financial Statistics*, April. CD-Rom.

Manne, Alan S., 2004. "Global Climate Change: An Opponent's Notes." Available at: www.copenhagenconsensus.com.

Mendelsohn, Robert, 2004. "Opponent Paper on Climate Change, Copenhagen Consensus." Available at: www.copenhagenconsensus.com.

Nordhaus, William D., and Joseph Boyer, 2000. *Warming the World: Economic Models of Global Warming* (Cambridge, Mass.: MIT Press).

Ramsey, F. P., 1928. "A Mathematical Theory of Saving," *Economic Journal*, 138, no. 152, pp. 543-59.