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# An Analysis of the Use of EPA's Benefit Estimates in OMB's Draft Report on the Costs and Benefits of Regulation

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# Executive Summary

Many advocates of regulatory reform recommend more and better benefit-cost analyses. Perhaps the single most ambitious and sophisticated such analysis ever conducted is the retrospective report on the benefits and costs of clean air recently completed by the Environmental Protection Agency. But EPA's estimates of trillions of dollars in benefits from the Clean Air Act depend on a few arbitrary assumptions about the nature and value of health improvements. Although a panel of well-respected scientists and economists reviewed the EPA's report, the Office of Management and Budget should not include it in its own report to Congress without more extensive discussion of key limitations. In particular, OMB should include a quantitative illustration of how alternative assumptions as plausible as those in the EPA report could shrink the expected value of benefits to a fraction of those reported.

**An Analysis of the Use of EPA's Clean Air Benefit Estimates**
**In OMB's Draft Report on**
**The Costs and Benefits of Regulation**

**Randall Lutter**

## 1. Introduction

Many advocates of regulatory reform recommend more and better benefit-cost analyses.[1] Perhaps the single most ambitious and sophisticated such analysis yet is the retrospective report on the benefits and costs of clean air recently completed by the Environmental Protection Agency under section 812 of the Clean Air Act.[2] To support the analysis, EPA staff and contractors prepared more than fifty separate background papers. In addition, the report went through six years of unprecedented "peer review" involving EPA's Science Advisory Board, whose members are noted and well-respected economists and scientists.

This paper is not intended to disparage the EPA's laborious effort. But it is designed to show the treacherous nature of the whole exercise of estimating the benefits of social regulation, of which the Clean Air Act is a key example. Assumptions underlying the estimates are often unavoidably arbitrary, they have large effects on the final results, and these effects are not always well explained.

The Office of Management and Budget is the government agency best placed – indeed mandated – to examine critically this EPA report as well as other cost-benefit analyses. This paper, therefore, takes the form of a series of recommendations to OMB in its task of assessing the EPA report. These recommendations are a simple means of showing how the benefit estimates could err, and why a different approach is at least equally plausible.

In any case, the benefit estimates for the Clean Air Act produced by EPA's section 812 report are remarkable, even more remarkable than the process that produced the report. The benefits during the period 1970–1990 ranged from $5.6 trillion to $49.4 trillion when valued in 1990.[3] The expected value of the monetary benefits in 1990 was $1.25 trillion per year, or about 20 percent of the gross domestic product in that year, while the upper estimate was $3.2 trillion.[4] The estimate of $3.2 trillion in benefits is roughly seventeen times greater than the previous estimates of Hahn and Hird.[5]

1. See, for example, Crandall et al. (1997) for recommendations on regulatory reform.
2. See U.S. Environmental Protection Agency, Office of Air and Radiation (1997), henceforth referred to as the section 812 report.
3. See EPA, OAR (1997, ES-8). According to the EPA there is only one chance in twenty that the true value of these benefits would fall outside this range.
4. See U.S. Office of Management and Budget (1998, 44043). In addition, table 1 indicates that the EPA's estimates of environmental benefits range from $378–3,222 billion in 1988 in 1996 dollars.
5. Robert W. Hahn and John A. Hird, "The Costs and Benefits of Regulation: Review and Synthesis." *Yale Journal of Regulation*, vol. 8, no. 1 (Winter 1991)

These large estimates are about to be more broadly accepted. When the EPA section 812 report was published it reflected the EPA's findings, but not necessarily those of other agencies because a pending court deadline prevented the concerns of some agencies from being resolved.[6] But now OMB, though it has not yet officially accepted the EPA estimates, has proposed to include them in its report to Congress on the Cost and Benefits of Federal Regulations.

While the OMB's draft of its report to Congress makes several insightful observations about the limitations of the benefits estimates in EPA's section 812 report, it overlooks significant deficiencies. In general, the conclusions of the section 812 report depend on several seemingly arbitrary assumptions about the nature and the value of the health benefits. Equally plausible alternative assumptions and approaches would lead to much smaller estimates of the benefits of the Clean Air Act. Therefore, OMB should not refer to the section 812 report without more extensive discussions of the limitations outlined here. In addition, OMB should show how alternative assumptions as plausible as those in the section 812 report could shrink the expected value of estimated benefits to a fraction of the values than EPA reported in its draft report.

To reiterate, the quantification of the benefits of the Clean Air Act depends almost entirely on how one values improvements in health. Valuing health benefits – diseases avoided – is not a precise science, though a large amount of scholarly effort has gone into this field. An informed judgment of the benefits of the Clean Air Act must include an awareness of how the dollar value of presumed health benefits turns on certain crucial assumptions.

In the next section of this comment I summarize the section 812 report. I then address analytical deficiencies that the OMB identified, but whose implications were not adequately explored and make specific recommendations to OMB. Next, I identify analytical deficiencies that OMB does not mention and again make specific recommendations to OMB. I present an illustrative calculation showing how estimated monetary benefits would fall by more than a factor of five using equally plausible alternative assumptions. At the end I draw general conclusions.

## 2. Summary of EPA's Section 812 Report

The section 812 report presents estimates of monetary benefits ranging from $5.6 to $49.4 trillion (present value in 1990 dollars) over the period 1970–1990, with a basic estimate of $22.2 trillion. The EPA's cost estimates were approximately $0.5 trillion.

6. See EPA, OAR (1997, 6).

The estimated benefits result from a series of linked analyses. First, EPA linked emission controls put in place between 1970 and 1990 to improvements in air quality. The agency then estimated improvements in public health or the environment that would result from these improvements in air quality. Finally, EPA valued these gains in health and environmental amenities by using existing estimates of how willing people are to pay for them. This analysis was not integrated with the cost analysis, which used the computable general equilibrium model developed by Dale Jorgenson and Peter Wilcoxen.[7] I focus on the separate benefits analysis because it apparently deviated more from accepted best practices.

A key limitation of the section 812 report is its lack of information on incremental benefits and costs. Apart from an implicit acknowledgement that lead and particulate matter controls offered large net benefits, the report did not describe the net benefits of particular pollution control programs.[8] It also did not identify programs that would have offered greater net benefits if controls had been either more or less stringent. Left unaddressed are questions about whether alternative legislation or implementation would have provided larger net benefits and if so, how much larger.

To ensure comparability with other estimates, OMB converts EPA's estimates of present value benefits into benefits for the year 1988 in 1996 dollars. In particular, it reports that estimated annual benefits from environmental regulations in 1988 ranged from $378 billion to $3,222 billion.[9] I focus not on these annual benefits but instead on EPA's underlying estimates of present value benefits.[10]

## 3. Analytic Issues

### 3.1 Deficiencies Identified by OMB but Inadequately Explored.

The OMB report carefully discusses some difficulties with the section 812 report and its interpretation, such as uncertainty about the quality of air that would have existed in 1990 in the absence of the 1970 Clean Air Act. It also addresses uncertainties about whether key categories of observed health effects are causally related to air pollutant concentrations and about the magnitude of these health effects. Finally, it addresses the timing of health effects and their valuation. In general, however, the OMB report does not adequately consider how these uncertainties affect the general benefits estimates.

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7. See, for example, Jorgenson (1993).
8. See EPA, OAR (1997, ES-10).
9. See OMB (1998, table 1). The derivation of these figures is not explained. It appears to be derived from the upper-bound estimate of $2,760 billion in benefits for 1990 that appears on page 54 of the retrospective report. This estimate is adjusted slightly to reflect 1988 benefits, and then converted to 1996 dollars.

**Recommendation 1: OMB should make clear that the baseline for the EPA's benefit estimates involves air quality in 1990 as bad as in the most polluted cities in the world. It should describe the deterioration between 1970 to 1990 that this baseline presumes.**

As noted by OMB, EPA's section 812 report attributes all the costs and benefits of all emissions controls put in place between 1970 and 1990 to the Clean Air Act. State, local, and private efforts receive no credit. While OMB properly points out that this simplifying assumption overstates the benefits (as well as the costs), it gives the reader little evidence of the magnitude of the overstatement. The section 812 report itself, however, gives some evidence. In particular, in EPA's baseline, sixty metropolitan areas in the United States would have had higher concentrations of total suspended particulate matter in 1990 than Moscow. Six metropolitan areas would have been worse than Bombay, and one would have had worse air quality than Delhi, one of the most polluted cities in the world.[11] Even in the absence of the Clean Air Act such rapid deterioration of air quality would probably not have occurred in a functioning democracy like the United States. Thus, this baseline leads to an overstatement of the benefits attributable to the Clean Air Act.

**Recommendation 2: Without clear evidence of a biological mechanism of action, OMB should work with EPA to develop estimates of benefits that (1) incorporate the possibility that the epidemiological associations do not measure causal relations and (2) reflect uncertainty about alternative nonlinear dose-response relationships including those considered in the risk assessment for the recent ambient air quality standard for particulate matter (PM).**

OMB notes that the section 812 report does not discuss key difficulties with interpreting the dose-response relationships estimated in the epidemiological literature. According to OMB, these difficulties include

- the absence of clear evidence regarding biological mechanisms of action for the various health effects of interest,
- uncertainties about the shape of the concentration-response relationships, and

10. The present value of the benefits is the discounted sum of benefits over the years 1970–1990.
11. See EPA, OAR (1997, 55).

- concern about whether the use of ambient particulate matter and fixed-site monitoring data adequately reflect the relevant population exposures to PM that are responsible for the reported health effects.[12]

These difficulties imply that benefits estimates based on the assumptions that epidemiological associations measure causal relationships and that the concentration-response relationship is linear fail to reflect the true range of possible benefits. OMB and EPA inappropriately failed to analyze the effects of the uncertainties regarding these points on the estimated benefits. Such an analysis is called for by OMB's guidance document on economic analysis of regulations, which states, "Where benefit estimates are heavily dependent on certain assumptions, it is essential to make those assumptions explicit and, where alternative assumptions are plausible, to carry out sensitivity analyses based on the alternative assumptions."[13]

Without an accepted biological mechanism to explain how PM at the observed concentrations can significantly increase the risk of human mortality, analysts must acknowledge that the epidemiological associations might not measure causal relationships. Plausible alternative interpretations of the epidemiological associations affect the evaluation of this possibility. One interpretation, proposed by Crandall, Reuter, and Steger,[14] involves air pollutants from indoor sources. Most people spend most of their time indoors and the chronically ill elderly, for whom the epidemiological associations are strongest, may spend virtually all their time indoors. In the United States, measurements of personal exposure to PM are higher than the PM concentrations measured outdoors because of indoor sources of particles, such as cooking, smoking, and cleaning.[15] Given that people spend a large majority of their time indoors and that PM concentrations are higher indoors, one might wonder whether pollutants from indoor sources are the true culprit. In this case, epidemiological studies might find an association between outdoor PM concentrations and health effects if outdoor concentrations correlated with indoor concentrations of pollutants from indoor sources. Crandall, Reuter, and Steger argue for the likelihood of such a correlation because greater wind velocities reduce PM concentrations both outdoors *and* indoors (by increasing the rate that the air inside buildings is exchanged for cleaner outdoor air). Unfortunately, the report cites no data to reject this plausible interpretation.[16] Thus, the observed associations might not be causal. If an analyst believed the likelihood that the associations were

12 See OMB (1998, 44045).
13. See OMB (1996, III.A.5).
14. Robert Crandall, Frederick Reuter and Wilbur Steger, "Clearing the Air: EPA's Self-Assessment of Clean-Air Policy," *Regulation* 4 (1996), pp. 35-46.
15. EPA, Office of Air Quality Planning and Standards (1996, IV-15). See also Brown and Paxton (1997).
16. The epidemiological studies rarely control for wind velocity. See, for example, EPA, OAQPS (1996, V-44), and Health Effects Institute (1997, 10). More direct evidence about indoor and outdoor pollution is inconclusive. See e.g., Brown and Paxton (1997).

causal was, for example, 95 percent, then an appropriate lower bound of the range would include zero benefits for PM-related mortality.

OMB also correctly stated that the section 812 report included an inadequate discussion of the uncertainty about the dose-response relationship, but OMB did not assess the importance of this uncertainty. Other EPA studies have assessed the implications of alternative dose-response relationships, however EPA's proposal for a national ambient air quality standard (NAAQS) for particulate matter noted that the PM risk assessment did not extrapolate the concentration-response relationships below the range of the PM air quality data reported by any given study.[17] In addition, the NAAQS proposal for particulate matter reported that "the data do not rule out the possibility of an underlying nonlinear, threshold concentration-response relationship."[18] In assessing the implications of nonlinear concentration-response relationships, the PM risk assessment for the NAAQS revision for PM used sensitivity analysis to develop ranges of estimated risks. Based on the results of these analyses, EPA concluded that the possible existence of a threshold, below which PM-related health risks are unlikely, represented the single most important factor influencing the uncertainty associated with the risk estimates.[19]

How does this uncertainty affect benefits? EPA's risk assessments for the fine particulate standard incorporated different thresholds in the dose-response relation. The estimated risk associated with PM exposures in Philadelphia County fell by a factor of two to six, depending on the value of various threshold concentrations of fine particulate matter. This difference cannot, however, be applied to the section 812 report without additional analysis.

**Recommendation 3: OMB should adjust the range of benefits estimates derived from the EPA section 812 report to reflect alternative assumptions about possible latency periods for mortality risk and for the onset of chronic bronchitis.**

The OMB report properly points out the failure to discount for delays between pollution controls and reduction in mortality in EPA's section 812 report. The analysis does not, however, estimate new aggregate benefits, given the fifteen-year delay that it supposes. OMB also does not mention that similar delays probably exist for chronic bronchitis. In fact, new cases of chronic bronchitis likely depend on exposure to particulate matter over a period longer than a year. A delay of fifteen years in the onset of these effects would reduce the

17. EPA (1996, 65651).
18. Ibid.
19. EPA (1997, 38656).

benefits by a factor of 2, while a delay of thirty years would reduce them by a factor of four.[20] EPA's use of an assumption that all benefits for chronic bronchitis occur in the same year as reductions in particulate concentrations clearly reflects a limiting case.

**Recommendation 4: OMB should clearly summarize the deficiencies in the contingent valuation-based benefits estimates for the value of chronic bronchitis.**

Although the OMB report addresses the valuation of changes in mortality risk, it is silent on the valuation of chronic bronchitis in the section 812 report. The section 812 report combines a broad measure of the incidence of chronic bronchitis with valuation estimates from Viscusi, Magat, and Huber[21] and from Krupnick and Cropper.[22] Both experimental research studies explored methodological issues associated with contingent valuation methods to estimate the willingness to pay (WTP) to avoid a health risk.[23]

The section 812 report estimated the value of avoiding a case of chronic bronchitis based on the responses reported by Viscusi, Magat, and Huber. Because this study used a severe case of chronic bronchitis, the section 812 report adjusted the estimate to lessen the severity by using the estimates from Krupnick and Cropper. Using results from these two experimental studies to develop an estimate of the value of a pollution-related case of chronic bronchitis raises serious concerns. An emerging literature sets out criteria for contingent valuation studies to serve as the basis for the valuation of commodities. In a 1994 proposed rule, for example, the National Oceanographic and Atmospheric Administration set out criteria for such studies, including (1) a survey instrument design (Does the survey instrument provide an understandable commodity definition and a credible choice mechanism?), (2) survey administration (Does the survey use a probability sample from the target population?); and (3) the nature of results (Do the results satisfy normal requirements for market behavior?).[24]

These two studies fail to meet these criteria in several important respects. First, Viscusi, Magat, and Huber specifically caution against the use of these willingness to pay estimates as a basis for the valuation of health effects because of the shortcomings in the design of their study. Second, in terms of survey design, 35–

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20. The section 812 report uses a real discount rate of 5 percent. This rate implies that a value grows by a factor of two over an interval of approximately fifteen years.
21. Kip W. Viscusi, W. A. Magat and J. Huber, "Pricing Environmental Health Risks: Survey Assessment of Risk-Risk and Risk-Dollar Tradeoffs," *Journal of Environmental Economics and Management* 201(1991), pp. 32-57.
22. Alan Krupnick and Maureen L. Cropper, "The Effect of Information on Health Risk Valuations," *Journal of Risk and Uncertainty*, vol. 5, no. 2 (1992), pp.29-48.
23. How much one is willing to pay to avert small risks to health is a standard measure of the value of averting such risks.
24. See U.S. National Oceanographic and Atmospheric Administration (1994, 1182–83).

40 percent of the respondents in this study gave inconsistent responses for each of the three tradeoff choices. Did the respondents adequately understand the choice mechanism in the survey? Krupnick and Cropper report inconsistent responses in the range of 20 to 25 percent for each tradeoff choice. These researchers suggest that the higher rate of inconsistent responses may result from differences in the way the survey was administered; in particular, Viscusi, Magat, and Huber conducted their survey in a shopping mall.

Third, these studies did not draw their subjects from a sample from the U.S. population as a whole. Viscusi, Magat, and Huber administered their survey to 389 subjects at one mall in North Carolina; Krupnick and Cropper used a modified version of that survey in interviews with 189 subjects in the Washington, D.C., area. The narrow geographic scope and the selection of subjects for the two studies make it unlikely that their results are representative of the U.S. populations as a whole.

3.2 Uncertainties and Deficiencies Not Mentioned by OMB.

OMB failed to mention several important limitations of the section 812 report.

**Recommendation 6: OMB's report should present the alternative estimates included in the section 812 report and point out the sensitivity of these estimates to equally plausible values for extensions to life and to assumptions about the years of life gained.**

EPA's Science Advisory Board requested that "alternative" benefits estimates be included in the section 812 report; however, the OMB draft report neglects these estimates. The alternative benefits estimates result from converting the reductions in mortality risk to years of life gained and then valuing these at $293,000 per life-year. This approach differs conceptually from the conventional one, in which all reductions in mortality risk are assumed to be of equivalent value regardless of their effect on the length of life. The alternative benefits estimates are $9.1 trillion (down from $16.6 trillion) for the value of improved life expectancy associated with reduced exposure to particulate matter.[25] The literature supports this alternative approach. In a letter to EPA Administrator Carol Browner, the Advisory Council on Clean Air Act Compliance Analysis, a part of EPA's Science Advisory Board, wrote:

> We believe that the values applied to statistical lives saved by the Clean Air Act should, in principle, reflect the health status of those saved and their remaining life expectancy. We also

25. EPA, OAR (1987, ES-9).

believe that the value currently applied to a statistical life, $4.8 million (1990 U.S. dollars), significantly overstates the value most people would attach to the average number of life-years saved (per person) by the CAA.[26]

Although this alternative approach may better reflect the "good" relevant to individuals–the duration of life–and is indeed more consistent with many studies of the cost-effectiveness of medical and public health interventions, its application here may be problematic[27]. First, the alternative results rely on a high value of $293,000 per life year. This value assumes the applicability of the formula for a constant annuity to the value of reducing mortality risk. The value exceeds estimates of the willingness to pay for extensions to life; admittedly, these are rare in the literature. One such figure comes out of Garber and Phelps, who model people's decisions to reduce risks to health over the life cycle. [28] They derive values generally less than $100,000 per life year, and show how these fall slightly with age. Second, this alternative calculation assumes that individuals dying of exposure to particulate matter lose the average life expectancy for their age group, a loss of 14 years per death averted.[29] An alternative assumption is that the individuals dying from exposure to particulate matter would have had a life expectancy less than the average members of their age group.

The epidemiological literature contains little evidence to substantiate alternative assumptions about how much longer people might live if exposure to fine particulate matter were reduced. One perspective on the fourteen year estimate, however, is a comparison to the effects of smoking. The Food and Drug Administration has estimated that a smoking death averted represents on average a gain of fifteen life years.[30] If chronic exposure to high levels of a contaminant as harmful as tobacco smoke costs fifteen years of life, exposure to relatively low concentrations of ambient pollution would seem plausibly to cost much less.

**Recommendation 7: OMB should explicitly state that the EPA section 812 report fails to incorporate potentially significant offsetting effects associated with ultraviolet-B exposure and should defer final acceptance of the results of the section 812 report until the agency concludes a serious study of the costs of such effects.**

The section 812 report presents no useful information about offsetting harmful effects of reduced air pollution, even when these are relatively well understood. One example of such an effect is screening of UV-B

26. Schmalensee (1996).
27. See Tolley, Kenkel, and Fabian, eds. (1994).
28. Alan Garber and Charles Phelps, "Economic Foundations of Cost-Effectiveness Analysis," *Journal of Health Economics* 16 (1997), pp.1-31.
29. EPA, OAR (1987, I-25).

solar radiation by tropospheric (low-level) ozone. Reductions in ozone near the ground, like the depletion of stratospheric ozone, increase exposure to harmful UV-B radiation. Such radiation is implicated in skin cancers, both melanoma and nonmelanomas, and in cataracts.[31] Lutter and Wolz show that existing methods can provide estimates of the resulting adverse effects on human health, and that these effects are likely to be significant relative to the value of respiratory health improvements from reduced ozone concentrations.[32] Although the Lutter and Wolz estimates pertain to a reduction in tropospheric ozone of ten parts per billion–and not for the reductions estimated either for the recently promulgated national ambient ozone standard or for the Clean Air Act in the section 812 report–UV-B effects for these reductions could be calculated with existing methods. As part of the risk assessment for the recent NAAQS, EPA developed methods to estimate reductions in tropospheric ozone at different points in the distribution of ozone concentrations.[33]

A second example relates to UV-B screening by aerosols or particles. Liu, McKeen, and Madronich write that "anthropogenic aerosols have the apparent beneficial effect of reducing UV-B radiation at the surface. [34] In this context, the effect is similar, and possibly larger, to that of increased tropospheric ozone."[35] The United Nations Environment Programme (UNEP,) in a summary intended to reflect a scientific consensus, states, "The tropospheric aerosol content of the atmosphere has been identified as a major factor in determining the amount of radiation reaching urban and suburban areas, and has been invoked qualitatively to explain negative trends in UV-B radiation at some urban locations."[36] Based on calculations by Liu, McKeen, and Madronich, UNEP suggests that since pre-industrial times, the daily dose of UV-B in midsummer at a latitude of 40 degrees north decreased by 8–20 percent, depending on the height of the affected air mass and current air quality. Since the section 812 report presents the visual range in selected cities both with the Clean Air Act and without emissions controls, a rough estimate of the increased midsummer daily UV-B dose for these cities is available. In Denver, for example, the CAA increased the visible range from 10.5 to 19.6 miles.[37] Applying the UNEP relationship, I estimate that the daily dose of UV-B increased by 9–15 percent, depending on whether the boundary layer is assumed to be one km or two km. Given these illustrative UV-B increases, deriving estimates of the additional incidence of skin cancer and cataracts attributable to given air quality

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30. U.S. Food and Drug Administration (1996, 44575).
31. United Nations Environmental Programme, *Environmental Effects of Ozone Depletion: 1994 Assessment*, Nairobi, 1994.
32. Randall Lutter and Christopher Wolz, "UV-B Screening by Tropospheric Ozone: Implications for the National Ambient Air Quality Standard," *Environmental Science and Technology*, vol. 31, no. 3 (1997), pp. 142a-146a.
33. For EPA's methods, see EPA, OAQPS (1997, 12-29).
34. S. C. Liu, S. A. McKeen and S. Madronich, "Effect of Anthropogenic Aerosols on Biologically Active Ultraviolet Radiation," *Geophysical Research Letters* 18 (1991), pp. 2265-68.
35. See Liu, McKeen, and Madronich (1991, 2266).
36. See United Nations Environment Programme (1991, 6).
37. EPA, OAR (1997, tables C-15 and C-16).

improvements is feasible with existing methods. Of course a careful analysis would have to assess uncertainty, including the significant uncertainty attributable to the relationship between PM and UV-B.

UV-B exposure also has adverse effects on plants and crops. EPA has estimated these effects in other contexts.[38] The section 812 report, however, estimated no such UV-B effects. Although UV-B related effects are not likely to be sufficient to reverse the conclusion that estimated clean air benefits exceed costs, their omission in the section 812 report suggests that the conduct of the study may not have been fully objective.

**4. Illustrative Example**

The key conclusion of the section 812 report is that benefits exceeded costs by a factor of more than forty. A different interpretation of the same data could lead to a substantially different conclusion. Such an alternative interpretation is presented in Table 1.

The nearly $17 trillion in expected mortality benefits from reduced PM concentrations would fall to about $1.1 trillion under reasonable alternative assumptions outlined as follows. EPA presents an alternative estimate based on the value of extending life. It yields an estimate of $9.1 trillion.[39] If these longevity gains occurred after a delay of fifteen years attributable either to the chronic nature of exposure or to a latency period between exposure and the onset of disease, then the benefits would fall by a factor of two to $4.5 trillion. If gains in life expectancy were valued at $100,000 per life year, according to Garber and Phelps, instead of $293,000, then these benefits would be worth $1.5 trillion. Indeed, other researchers have used estimates of $100,000 per life year.[40] Finally, if the epidemiological associations were interpreted as reflecting causal relationships with only 0.75 probability, then the expected value of this benefit category would fall to $1.2 trillion. These adjustments do not reflect uncertainty about the number of years of life gained.

For chronic bronchitis, if there were a delay of fifteen years attributable either to the chronic nature of exposure or to a latency period between exposure and onset of disease, then estimated benefits would fall from $3.3 trillion by a factor of two. As with mortality, the lack of corroborating clinical and toxicological evidence suggests that the observed epidemiological relationship may not be causal. If it is causal with only 0.75 probability, then this benefit estimate would fall to $1.2 trillion. This estimate does not reflect an adjustment

38. EPA, OAR (1987).
39. EPA, OAR (1997, table ES-5).
40. David Cutler and Elizabeth Richardson, “Measuring the Health of the U.S. Population,” *Microeconomics 1997, Brookings Papers on Economics Activity* (Washington, D.C.: Brookings Institution, 1997), pp. 217-271.

to the willingness to pay to avert chronic bronchitis, though the WTP estimates derived from the contingent valuation studies described above exceed the cost of illness for people aged sixty by about a factor of six.[41]

On the basis of only these three adjustments to two categories of benefits, the estimates for expected aggregate benefits would fall by a factor of five, to $4.5 trillion. Although I make these adjustments to the mean present value estimates, they also apply to the upper- and lower-bound estimates used by OMB. But the range of estimated benefits must not dominate our understanding. EPA and OMB both note correctly that the estimated benefits necessarily exclude some that have not been quantified or expressed in monetary terms. Similarly, some deficiencies identified in the EPA estimates are not amenable to easy numerical corrections, though they are also important. For example, the neglect of offsetting UV-B effects and the use of a single baseline representing a limiting case are harder to correct without additional research. Nonetheless, if such deficiencies were incorporated, they would further lower estimated benefits.

## 5. Conclusions

The estimates of clean air benefits in EPA's section 812 report rely on several key assumptions that are not well identified. For example, EPA assumes that all reductions in health effects occur in the same year as reductions in air pollution and that epidemiological associations are unbiased estimates of causal relationships, even though there is no accepted biological mechanism.

Equally plausible alternative assumptions would lead to benefits estimates that are a small fraction of those estimated by EPA. OMB should use illustrative calculations to show that EPA's estimated range of benefits depends on a few arbitrary assumptions and that alternative assumptions would substantially change the range of estimated benefits.

41. EPA, OAR (1997, p. I-5).

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Table 1

## CLEAN AIR BENEFITS: ILLUSTRATIVE ALTERNATIVE ESTIMATES

| Category of Benefits | | EPA "Best" Estimates | **Illustrative** Alternative Estimates | Basis for Alternative Estimates |
|---|---|---|---|---|
| Pollutant | Endpoint | | | |
| Particulate Matter | Mortality | $16,632 | $1,200 | 1) Mortality reductions follow emissions reductions by 15 years. 2) Epidemiological associations measure causal with 3/4 probability. 3) Extensions to life are valued at $100,000/life-year. |
| | Chronic Bronchitis | $ 3,313 | $1,200 | 1) Chronic bronchitis reductions follow emissions reductions by 15 years. 2) Epidemiological associations are causal with 3/4 probability. |
| Lead | Mortality | $ 1,339 | $1,339 | No change |
| All Other Benefits | Hospital Admissions, etc. | $ 890 | $ 890 | No change |
| PM, Ozone | UV-B effects on health | Not addressed | Not available | See Lutter and Wolz (1997). |
| Total | All | $22,171 | <$4,600 | Excludes adjustments for UV-B and baseline air quality. |

Note: Benefits are for the period from 1970 to 1990, in 1990, in billions of 1990 dollars.