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Ronald Evans is not the first person to refer to economics as the "dismal science." But, I think of economics as a happy science. The economist Julian Simon, who recently passed away, was able to show, through his work in the environmental field, that we are not running out of resources. In fact, the price of many of our natural resources is coming down all the time. That is a happy thought to me.

Another happy thought is Title IV of the Clean Air Act (CAA).[1] The economists' idea of tradable permits is a political compromise and a cost-effective solution to reduce sulfur dioxide (SO_2) emissions from existing sources by about half.

I will discuss the role of economics in standard setting, particularly the new National Ambient Air Quality Standards (NAAQS) for ozone and Particulate Matter (PM). I argue, as Bill Peterson did, that the criteria of Section 109[2] make it appear that cost/benefit analysis is not part of the

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1. 42 U.S.C. § 7651 (1994).
2. 42 U.S.C. § 7409(d).

decision. I will come back to that later. But regardless of what Congress legislated over twenty-five years ago, trade-

Figure 1: Basics of Benefit-Cost Analysis (BCA)

- Technique to compare from society's point of view what is obtained and what is given up from a course of action
- Emphasis on efficiency—getting the most from society's scarce resources
- Not equity; but BCA not sole evaluative criterion
- Requires common single metric: the "value" people place on changes from a baseline
- "Value" is a theoretical construct inferred from choice; can be stated or revealed; measured as willingness to pay or accept.
- Not an economic impact assessment

offs are a fact of life. When you want to get something, you have to give something up. To minimize the use of your scarce resources, you have to take tradeoffs into account.

Failure to take the high costs into account when setting ambient air quality standards also results in lawsuits and delays. The Presidential Directive, issued along with the new standards, basically says, "Look, we will give you (EPA) your standards for fine PM, but you don't get them for five years at

Figure 2: Role for Economics in Setting the NAAQS

- Criteria in the CAA: Protect health with a margin of safety→no role for BCA
- But:
  - Tradeoffs a fact of life
  - E.O. 12866 requires it
  - Stakeholders want to know
  - Useful for implementation

a minimum, and only after another review of the health evidence. And it does not get implemented fully until 2018." Now, to me, this is an extremely cynical outcome. As a citizen, I am outraged by this because if you believed Administrator Browner of EPA when she said that thousands of lives are at stake each year due to the new air quality standards, how can she then turn around and say that we are not going to do anything about it for at least five years, and then wait twenty years to meet the standards?

What I would have preferred is a standard that took account of cost and benefits. It might have been a weaker standard, but one that is actually enforceable and that EPA can act upon as quickly as it possibly can. I do not think that happens here. You cannot get around tradeoffs. Even if you do not want to do it on philosophical grounds the Executive

Order 12866, and every Executive Order in this area since President Nixon's term, requires EPA to do a cost/benefit analysis of major rules. So, EPA had to do it and that probably is the main reason why they did it.

Of course, there are many stakeholders who want to know about these costs and benefits. They want to know if the country, as a whole, will be better off. Hopefully, EPA is being responsive to them as well. Finally, I would agree with Administrator Browner that the cost/benefit analysis techniques and actual analyses that were done by EPA are quite useful for implementation of the standards. By doing a cost/benefit study, where you analyze costs of different technologies and different economic incentive approaches, to look at how much emission reduction and ozone and PM reduction you get, you obtain very useful information for devising future implementation strategies.

So, there are many reasons to do a cost/benefit analysis of these regulations.[3] Even if these analyses cannot explicitly (legally) be considered for standard setting, they are implicitly considered anyway, as they were this time. I want to turn for a moment to the cost/benefit analysis that EPA did to address these standards.

The first thing that I want to say is that I think Ron Evans and the economists in his group at EPA deserve a great deal of praise for the way that they did the analysis. They work under very political conditions and they are short money and resources, because EPA does not assign these types of analyses a high priority. Given the belief that this cost/benefit analysis cannot affect setting standards, you cannot blame EPA for this allocation of its resources. Thus, it is hard to do a high quality cost/benefit study within EPA and they did the best job they could. They were also responsive to outside comments and I am quite pleased by that.

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3. *See* National Ambient Air Quality Standards for Ozone, 62 Fed. Reg. 38,856 (1997) (to be codified at 40 C.F.R. pt. 50); National Ambient Air Quality Standards for Particulate Matter, 62 Fed. Reg. 38,652 (1997) (to be codified at 40 C.F.R. pt. 50); Revised Requirements for Designation of Reference and Equivalent Methods for $PM_{2.5}$ and Ambient Air Quality Surveillance for Particulate Matter, 62 Fed. Reg. 38,764 (1997) (to be codified at 40 C.F.R. pts. 53, 58).

Figure 3: Are There Net Benefits to Society From the New Standards?

- Kudos to EPA for admitting possibility that C>B

- Cost Issues
  - Partial vs. full attainment
  - Low-ball engineering cost estimates?
  - Limited treatment of innovation or economic incentives
  - Uncertainty
  - Substitution risks

- Benefit Issues
  - Mortality C-Rs: interpretation, thresholds
  - Mortality valuation: EPA vs. OMB; current vs. future risk changes
  - Valuing a case of chronic bronchitis
  - Avoiding costs

In fact, the results for ozone and $PM_{2.5}$ are basically the same numbers that Ron Evans gave you. For EPA to show negative net benefits in this final attainment case, i.e., that costs outweigh the benefits, is in my view an indication of EPA's attempt to do an honest, straight-forward analysis and call it as they see it. I give them kudos for that.

So now, I will turn to some of the specifics of these numbers to examine how credible they are. I want to say a little about the costs. Notice that EPA provides no indication of how uncertain these costs are. Figure 5 is a graph that I put together on incremental or marginal costs, for reductions in

Figure 4: Incremental Annual Benefits and Costs of New Standards in 2010 ($ bil. 1990)

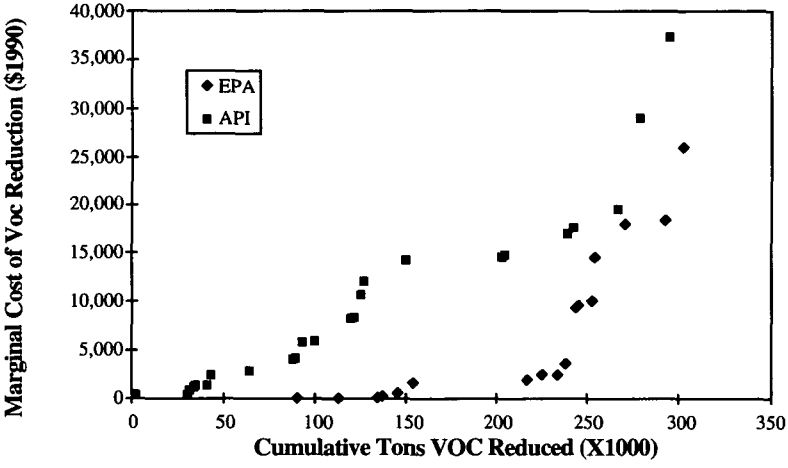
Category	Ozone	PM2.5
	Partial	Partial
Costs	1.1	8.6
Benefits	0.4-2.1	19-104
Net	(0.7) – 1.0	10 – 95
# NA counties	17	30
Benefits	0.4-2.1	19-104
Without mortality: PM		17 – 29
Ozone	0.4 - 1.7	
Ozone + PM	0.4 - 0.5	
without chronic bronchitis	0.4 – 0.4	5 – 10

- API Study: $2.3 billion in costs for (not) meeting (somewhat tighter) new ozone standard for 4-state Great Lakes Region

volatile organic compounds (VOCs) in a four-state region around the Great Lakes and Chicago. On the vertical axis is the marginal cost of these reductions and on the horizontal axis is cumulative tons of VOCs reduced. EPA estimates are the diamonds and the American Petroleum Institute (API) numbers are the pink squares. Now, I will not claim that API is a less unbiased actor in its study than EPA is in its study. Nevertheless, one can see an enormous difference between these sets of numbers. What you want to look for are the ar-

eas under these curves, as an estimate of the total cost of reaching any amount of tons reduced. When you do that, you find that the API study shows estimates of $1.1 billion in costs for meeting a somewhat tighter new ozone standard for a four-state region. This is in contrast to EPA's cost, which is also about $1 billion, but for the *entire nation.* Something funny is going on here.

Figure 5: Marginal Cost of VOC Reduction in Chicago Region EPA vs. API



What is disappointing about the EPA study is that the API estimates, and those from other groups, were not in any way integrated into the study, making it impossible for the general public to gauge the uncertainties associated with the costs. API's estimate is probably way too high and EPA's is probably way too low, but we have no way of judging, unless EPA takes a more scholarly approach.

There are two other issues that may work in the other direction. EPA did not look much beyond engineering approaches to reducing pollution. There are a wide array of economic incentive approaches that could be used that would reduce pollution more cost-effectively. At the same time, they did not integrate the possibility into the analysis that there

would be technological innovation, over time. Of course, that would reduce the costs as well. In response to a question that was asked this morning, it is possible to project technological changes. You cannot foresee the new technology that will be designed based on what you know now, but you can look back in time. One looks historically at the pace of technological innovation to see how cost per ton changes over time. One can make some estimates and try to get at these very hard problems. At least such an analysis can give people a better sense of the pace of technological change and provides a credible alternative to using, as EPA did, the $10,000 per ton fudge values. In my view, costs would be much greater to meet the standard if there was a real estimate here. The benefits would increase as well, but not as fast.

I want to talk a little about benefits and then talk more about the normative role of cost/benefit analysis. On figure 4, I repeated the benefit estimates in order to show the importance of the effects of PM on mortality risk in the analysis and the effects of PM on the risk of developing a case of chronic bronchitis. You start off with $19 billion to $104 billion of benefits. If you take out the PM and mortality effect, you are down to $17-29 billion. If you take out the chronic bronchitis effect, you are down to $5-10 billion, against a cost of $8.6 billion. I am not saying that these effects should be taken out. I am just saying that this is where the action is, this is where we have to look. Interestingly, that is also where the action is in the ozone analysis, because if you take out the ozone mortality effect from the benefits, it only affects the high estimates. It falls a little bit from $2.1 to $1.7 billion. More important are the benefits from the NOx reduction that reduce ammonium nitrate, which is counted as a fine particle. If you took this effect out, benefits would fall dramatically.

Therefore, PM mortality and PM chronic bronchitis are the entire story. I am not going to talk about health effects, except for the way in which we describe them. But, I do want to talk about value. The first thing to understand about valuing mortality risk is that when economists talk about values and lives, we are not talking about valuing your grand-

Figure 6: Presenting and Valuing Mortality Change

Appears in:	Effects	Values
RIA-High (EPA)	"Body Count"	$4.8 mil/death delayed
RIA-Low (OMB)	Life year	$120,000/life-year
New research; *Sulfur in Gasoline Report* Canadian Government	Change in life expectancy	$1,500 for treatment at 75 to extend life expectancy from 85 to 86

mother's life, or even your own life. What we are talking about is trying to tease out, from people's behavior, their willingness to pay for small changes in their risks. People in all walks of life make this decision all the time. Not only in purchasing insurance policies: you make it every time you decide to go a little faster on the highway to get to an appointment earlier. You are increasing your risk of death, but saving time is worth something to you. You make that kind of tradeoff. The trick is to try to estimate that and determine what people's preferences really are for reducing their risk of death. As economists, we do not make up these numbers. It is what you tell us by your actions. So, the value of a statistical life (VSL), a technical term you may have heard of, is the average willingness to pay for a risk reduction divided by that risk reduction. That is all it is. So, if people on average are willing to pay a hundred dollars to get a one in 10,000

reduction in their risk of death, then the value of a statistic life is $1 million. This is a traditional approach to how economists treat this issue. You get these estimates mostly from wage compensation studies, where individuals in the labor market who are working in the riskier industries are found, to receive wage premiums. They earn higher wages, because they take more risks, other things being equal. These estimates are obtained from very detailed statistical analysis and there are many such studies.

These VSL's tend to range from $1 to $10 million and EPA used $4.8 billion in its cost/benefit analysis, which is a standard number. I even use it in my own analyses sometimes. What is the problem with using this kind of analysis and this number? Well, these studies primarily involve healthy individuals who are of prime age with life expectancy of about thirty-five additional years, on average. They are being compensated for risk of accidental death, risks being realized today. From several studies, PM does not appear to affect the young and healthy, but rather the old and frail. Eighty-five percent of effects are estimated to occur in people over sixty-five years old, so maybe they have an average of a few years to fourteen years life expectancy and the risk is not immediate death for most people. Thus, your willingness to pay for a change in pollution today must take into account that there will be virtually no effect, until you are older. Temporality has to be taken into account in these estimates. It is not taken into account in the traditional labor market studies. I should note that there is recent epidemiological literature concerning children. It may be that if we look at the effects of PM on children, there will be very large benefits. I do not know how that will come out. There has been very little research on both the health effects on children and how to go about valuing it.

As referenced in Figure 6, the "high" estimates describe the effects in body count terms, the number of deaths avoided without respect to age or the life expectancy differential. The VSL is $4.8 million per deaths avoided, so you must multiply the bodies by the VSL to obtain the $75 billion estimate of benefits. The other "low" estimate was a result of a compro-

mise within the administration, led by Office of Management and Budget (OMB) to use a $120,000 per life year figure. What this does is to allow you to use a lower life expectancy estimate to make some correction for the older people who are at risk. The $120,000 figure is derived from some of the lower VSL estimates. But, there is new valuation research and some of this research is described in a study that George Thurston and I did with some other folks for the Canadian Government, which involves describing the effect of PM as a change in life expectancy. If you look at the Pope study, it turns out that the change in life expectancy, caused by a one microgram per cubic meter annual change in particulates, is a couple of days. These effects are tiny, although they apply to a lot of people. So, it is not immediately obvious that these are trivial in the aggregate, but the way you describe them can make a big difference in how people perceive the size of these effects. There is also new research on valuation. The article by Johannesson and Johannson has a lot of problems. I am not relying on it in my research. But it asks about the right question: "Are you willing to pay for a medical treatment at seventy-five years old to extend your life expectancy from 10 years to 11 years (to eighty-six years old)?" The average value they find is $1,500 and the implicit VCLs range from $70,000 to $110,000. This survey was actually done in Sweden, not the United States. However, we are trying to do a similar study here. If you use this kind of approach, maybe the benefits fall by an order of magnitude to $7 billion. You cannot really rely on this study, but it certainly suggests a new direction.

In closing, I want to make a couple of recommendations. I think EPA should do research on the willingness to pay for changes in risks or life expectancy later in life and for today's older people. EPA should develop protocols for incorporating economic incentives and technological change into its analyses. In terms of its role in setting the NAAQS, the government has to lead the country in recognizing that tradeoffs have to be considered fundamentally in setting environmental policy. I do not see this happening in the Clinton Administration. I think that if the Administrator faces enormous

Figure 7: Recommendations for:

BCA Practitioners

1. Incorporate WTP for risk changes later in life

2. Develop protocols for incorporating incentives; all current and future technological options

scientific uncertainty over exactly where to set the standard and is told that even a tiny movement in that standard could result in millions, even billions of dollars difference in costs, a cost/benefit analysis should be used to inform the Administrator's policy judgment.

Finally, if changes in the CAA to incorporate cost/benefit analysis are admitted, I have two ideas. One is to set minimum health standards and then require justification for setting a tighter standard by using cost/benefit analysis. I am not suggesting that we subject the NAAQS to a strict cost/benefit test. Secondly, use cost/benefit analysis to set allowable exceedences (the number of days the standard may be violated before an area is declared in nonattainment). If five allowable excesses of the new ozone standard were allowed per year, averaged over three years, instead of two, 125 regions would be in compliance that would not be otherwise. So, when we face decisions that are this costly and this much hassle for every area that has to do a State Implementation Plan (SIP), if it is designated non-attainment, not to use cost/benefit analysis seems foolish and wasteful.