

appropriate in this case made in the 1990s ranged from 1 to 3 percent per annum.<sup>22</sup>

A second reason for discounting the benefits and costs accruing to future generations at a lower rate is increased uncertainty about the appropriate value of the discount rate, the longer the horizon for the analysis. Aversion to uncertainty discourages any such long-term investments. Private market rates provide a reliable reference for determining how society values time within a generation, but for extremely long time periods no comparable private rates exist. Symmetric uncertainty would have the effect of lowering the discount factor applied to future costs and benefits. Again the reasonable range might be expanded to include rates as low as 1 percent per annum.

If you choose to use a lower discount rate for intergenerational analysis, you should still be sure to show the calculated net benefits using discount rates of 3 and 7 percent as well. Discounting is appropriate whether you are doing a BCA or a CEA. Even costs and benefits that are not expressed in monetary units should be discounted if they are separated in time. This also includes health benefits for reasons discussed above. For example, in its 1998 rule, "Control of Emissions from Nonroad Diesel Engines," EPA estimated cost-effectiveness by discounting both the monetary costs and the emission reduction benefits over the useful expected life of the engines at the 7 percent real rate recommended in OMB Circular A-94.

It may be possible in some cases to avoid discounting non-monetized benefits, if the expected flow of benefits begins as soon as the cost is incurred and if it is expected to be constant over time. In such cases, annualizing the cost stream is sufficient, and further discounting of benefits is unnecessary. As an example, such an analysis might produce an estimate of the annualized cost per ton of reducing emissions of a pollutant.

#### *D. Treatment of Uncertainty*

The precise consequences (benefits and/or costs) of regulatory options are not always known for certain, but the probability of their occurrence can often be predicted. The important uncertainties connected with your regulatory decisions need to be analyzed and presented as part of the overall regulatory analysis. Your analysis of uncertainty should consider both the quantifiable risk associated with the potential outcomes of alternative regulatory actions (for example, the expected change in the distribution of automobile accidents that might result from a change in automobile safety standards) and the incomplete knowledge or uncertainty about the relevant relationships (for example, the uncertain science of how some economic activities might affect future climate change).

The treatment of uncertainty must be guided by the same principles of full

disclosure and transparency that apply to other elements of your regulatory analysis. Any data and models that you use to analyze uncertainty should be fully identified. Inferences and assumptions used in your analysis should also be identified, and your analytical choices should be explicitly evaluated and adequately justified. Your presentation should explain how your analytical choices have affected your analysis.

Uncertainty arises from various and fundamentally different sources. These include the fundamental unpredictability of various natural and social phenomena, but they also include lack of data and the lack of knowledge about key relationships resulting from limitations in fundamental scientific knowledge (both social and natural). The different sources of uncertainty suggest different approaches for dealing with it. For example, when the uncertainty is due to a lack of data, you might consider deferring the decision, as an explicit regulatory alternative, pending further study to obtain sufficient data. We recognize that delaying a decision will also have costs, as will further efforts at data gathering and analysis. You will need to weigh the benefits of delay against these costs in making your decision. Formal tools for assessing the value of additional information are now well developed in the applied decision sciences and can be used to help resolve this type of complex regulatory question.

In some cases, the level of scientific uncertainty may be so large that you can only present discrete alternative scenarios without assessing the relative likelihood of each scenario quantitatively. For example, in assessing the potential outcomes of an environmental effect, there may be a limited number of scientific studies with strongly divergent results. In such cases, you might present results from a range of plausible scenarios, together with any available information that might help in qualitatively determining which scenario is most plausible.

Your analysis should include two fundamental components: A quantitative analysis characterizing the probabilities of the relevant outcomes and an assignment of economic value to the projected outcomes. It is essential that both parts be conceptually consistent. In particular, the quantitative analysis should be conducted in a way that permits it to be applied within a more general analytical framework, such as BCA. Similarly, the general framework needs to be flexible enough to incorporate the quantitative analysis without oversimplifying the results. For example, you should address explicitly the implications for benefits and costs of any probability distributions developed in your analysis.

#### *1. Quantitative Analysis of Uncertainty*

Examples of quantitative analysis, broadly defined, would include formal estimates of the probabilities of environmental damage to soil or water, the possible loss of habitat, or risks to endangered species as well as probabilities of harm to human health and safety. There are also uncertainties associated with estimates of economic benefits and costs, e.g., the cost savings associated with

increased energy efficiency. Your analysis should be credible, objective, realistic, and scientifically balanced. In your presentation, you should delineate its strengths along with any lingering uncertainties about its conclusions. You should describe the assumptions and the models you used and their impact on the overall analysis. You should also discuss the quality of the available data used.

As with other elements of regulatory analysis, you will need to balance thoroughness with the practical limits on your analytical capabilities. Your analysis does not have to be exhaustive, nor is it necessary to evaluate each alternative at every step. In the absence of adequate data, you will need to make assumptions. These should be clearly identified and consistent with the relevant science. Your analysis should provide sufficient information for decision-makers to grasp the degree of scientific uncertainty and the robustness of estimated probabilities, benefits, and costs to changes in key assumptions. For major rules involving threshold costs of \$1 billion, you should present a formal quantitative analysis of the relevant uncertainties.

In your analysis, you should try to provide some estimate of the probability distribution of risks with and without the regulation, and you must do this for rules that exceed the \$1 billion threshold. In characterizing the probability distributions quantitatively, you should provide some estimate of the central tendency (e.g., mean and median) along with any other information you think will be useful such as ranges, variances, specified low-end and high-end percentile estimates, and other characteristics of the distribution.

Your estimates cannot be more precise than their most uncertain component. Thus, your analysis should report estimates in a way that reflects the degree of uncertainty and not create a false sense of precision. Your analysis should not reflect any unstated or unsupported preferences, even for such worthy objectives as protecting public health or the environment. Unstated assumptions can affect the analysis in unsuspected ways, making it difficult for decision-makers to evaluate the true magnitude of the uncertainties involved.

#### *Acceptable Analytical Approaches:*

Whenever possible, you should use appropriate statistical techniques to determine a probability distribution of the relevant outcomes, and for rules that exceed the \$1 billion threshold a formal quantitative analysis is required.

You may consider the following analytical approaches. They entail increasing levels of complexity:

- Disclose qualitatively the main uncertainties in each important input to the calculation of benefits and costs. These disclosures should address the uncertainties in the data as well as in the analytical results. However, major rules above the \$1 billion threshold require a formal treatment.
- Use a numerical sensitivity analysis to examine how the results of your analysis vary with plausible changes in assumptions, choices of input data, and alternative analytical approaches. Sensitivity analysis is especially valuable when the information is

<sup>22</sup> Approaches to discounting across generations are discussed in a recent symposium volume published by Resources for the Future. Paul R. Portney and John P. Weyant (eds.), *Discounting and Intergenerational Equity*, Washington, DC: Resources for the Future, 1999.