REGULATORY IMPACT ANALYSIS: BEST PRACTICES IN OECD COUNTRIES
ORGANISATION FOR ECONOMIC CO-OPERATION
AND DEVELOPMENT

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MEILLEURES PRATIQUES DANS LES PAYS DE L'OCADE

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IMPROVING THE ANALYTICAL BASIS FOR REGULATORY DECISION-MAKING

by

W. Kip Viscusi

1. INTRODUCTION

Government regulation takes many forms. Regulations that govern economic behaviour affect pollution decisions, transportation rates, prices of different commodities, and virtually every aspect of our lives.

Although the regulatory decision is generally based on an assumption that there is some inadequacy in market operation, economics nevertheless plays a constructive role in indicating how we should approach the choice of a regulatory policy. What is the rationale for different kinds of intervention in regulatory contexts? What are the merits of different kinds of regulation? How stringent should these regulations be? How should we choose among the different regulatory alternatives before us in a manner that is in society's best interests?

The purpose of this paper is to delineate the role of economics in answering these questions. The alternative to avoiding systematic analysis is a more casual approach to policymaking that is frequently followed in the initial periods of regulation. As society becomes increasingly aware of the costs that must be borne as a result of regulatory policies, however, governments have made efforts to ensure that these programmes are designed to use society's resources as effectively as possible. This paper will discuss the essential methodologies used to approach regulatory issues in an analytical manner.

The primary focus will be on topics pertaining to social regulation, particularly policies that affect human health and safety and the environment. Because the ultimate objective of these efforts is to influence outcomes not generally traded in explicit markets, some policymakers may be more reluctant to use economic principles to assess these regulations. Establishing appropriate prices for electricity generated by a publicly owned electric power plant has familiar market analogs. In contrast, determining how stringent to make highway safety
<table>
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<th>Concept</th>
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<tr>
<td>Benefit-cost analysis</td>
<td>Regulation is desirable if estimated benefits exceed the costs.</td>
<td>Reflects both favourable and adverse effects of a regulation and the need to ensure that, on balance, policies are in society’s best interests.</td>
<td>Some important benefit components may not be quantified and consequently given less weight. Criterion is less compelling if those adversely affected by a policy are not compensated.</td>
</tr>
<tr>
<td>Cost-effectiveness analysis</td>
<td>Calculation of cost per unit benefit achieved. Policies that can generate the same or greater benefits at no greater cost are preferred.</td>
<td>Eliminates the clearly inefficient policies from consideration and provides an index of the relative efficacy of policies in generating benefits.</td>
<td>Does not resolve the choice of the optimal level of benefits. Criterion is inconclusive when different benefit levels are generated and one policy does not produce greater benefits at less cost.</td>
</tr>
<tr>
<td>Risk analysis</td>
<td>Quantitative assessment of the magnitudes of the risk affected by the policy and their associated health consequences.</td>
<td>Provides decision makers with a sense of whether the policy will be effective in reducing risks in a significant manner.</td>
<td>Risk impacts may be diverse and not commensurate. Does not address the costs of achieving risk reduction or assess policy impacts other than risks.</td>
</tr>
<tr>
<td>Risk-risk analysis</td>
<td>Comprehensive assessment of all risk effects of a policy, including those in response to costs, to ensure that, on balance, policy reduces risk.</td>
<td>Serves as a more complete form of risk analysis and provides a limited recognition of other regulatory effects insofar as they influence costs.</td>
<td>Does not recognize other effects of regulation that ultimately do not affect risk; risk impacts may be diverse and not commensurate.</td>
</tr>
<tr>
<td>Cost assessment</td>
<td>Assessment of the costs of regulation on businesses, consumers, and workers. May include attempt to ensure that cost levels are not too high.</td>
<td>Attempts to comprehensively determine the total price society is paying for the regulation and provides insight into its economic feasibility.</td>
<td>Does not address the benefits of the regulation or ascertain the extent to which particular levels of costs are warranted by the favourable effects of the regulation.</td>
</tr>
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standards or the degree of genetic risk that we should allow workers to incur involves trade-offs of a quite different sort.

The use of systematic regulatory analysis will enable policymakers to understand the consequences of regulation and the optimal allocation of society's resources. Regulatory analysis need not lead to either more or less regulation than would result with an unstructured approach to decision-making, but it should lead to more efficient and effective policies. Moreover, regulatory policies should ideally foster, or reduce as little as possible, economic growth and competition. When there is conflict between economic and other regulatory objectives, there should be some mechanism for ensuring that the balance struck is in society's best interest. Regulatory analysis is intended to support such trade-offs.

Table 1 provides a summary table for several of the analytical techniques considered in this paper. These techniques, ranging from comprehensive attempts to assess the benefits and costs of regulation to more limited techniques, include:

- benefit-cost analysis;
- cost-effectiveness analysis;
- cost assessment;
- benefit assessment;
- discounting;
- risk assessment;
- risk-risk analysis.

Although none of these approaches is without limitations, examining each of these techniques will illustrate the different dimensions of policy effects that must be considered and how they relate to criteria for sound regulatory policy.

2. THE ROLE OF MARKET FAILURE

A fundamental tenet of economics is that markets serve an essential function. By ensuring that goods and services are allocated to individuals based on value and by providing the appropriate incentives to lead participants in the economy to take the necessary actions to ensure production of these goods and services, markets function as a resource allocation mechanism. If markets function fully effectively, then economists would pronounce the outcome efficient, and there would be little rationale for government regulation.

However, the idealized assumption of a fully competitive economy is seldom fully satisfied. Historically, two types of regulation have developed in response to inadequacies in the market: economic regulation and social regulation. Economic regulations of various kinds have a long history, as countries have sought to deal
with more traditional types of market failure such as that associated with monopoly power.

Increasingly over the last two decades, the emphasis of regulatory efforts has shifted from economic regulation to social regulation. Regulatory concerns dominating the policy agenda today involve issues such as greenhouse warming, nuclear safety, consumer protection, equal opportunity/equal access for the handicapped, job safety, the effect of pollution on health, and more generally environmental quality. In the United States, the largest contributor to new regulatory costs is environmental regulation.

Social regulation is likely to increase in relative prominence. Economic regulations are already well established and, in many cases, are becoming unnecessary as increased global competition and development of national economies has created a more competitive environment that is less in need of government restraints. In contrast, social regulation concerns have emerged more recently and are likely to become increasingly important as societies' affluence and demand for social protections increases. The development of a global economy also creates new classes of regulatory problems, as policies to address climate change and the preservation of scarce natural resources assume a larger dimension.

Many of these newer social problems require different approaches to analysis. For example, the rationale for regulation in the areas of risk and environmental quality is different than for economic regulation. Here the issue is not excessive market concentration, but rather that adverse risks are not priced adequately in markets, for two reasons. First, there is often no explicit market transaction whereby the party bearing the risk is compensated by the party inflicting risk for the harm that has been done. Victims of air pollution, for example, are engaged in no market relationship with the polluter. Second, in situations in which there is such a relationship, such as for workers on hazardous jobs, there may be no adequate market compensation for other reasons. For example, if workers are ignorant of the risks they face in their jobs, there will be no risk compensation.

The fact that there is a market failure does not in and of itself mean that all forms of regulation will be beneficial. Market failure simply creates a potential role for government action. For the government action to be worthwhile, one must show that overall these regulatory policies enhance social welfare. How one should make judgements with respect to social welfare and the impact of regulation is the main subject of the remainder of this paper.

3. FORMULATION OF REGULATORY POLICY OBJECTIVES

In any policy context, whether it involves regulation or not, the government must specify the objectives it wishes to promote. At the most basic level, these objectives are simply a list of concerns relevant to evaluating the desirability of a
policy. Specification of the objective of government policy is in many respects similar to specifying the preferences for an individual within the context of individual decisions. In particular, we need to know what criterion is being maximized through government policy.²

Stating that it is important to formulate policy objectives may appear to be an obviously rudimentary step in any policy assessment. Yet, often there is no clear articulation of prominent policy concerns. The advantage of developing a detailed specification of objectives is that one will be more confident that all pertinent concerns have been recognized and incorporated into the analytical and policy assessment process.

Articulation of objectives is also essential to highlighting what trade-offs must be made in pursuit of these policy objectives. All policies involve competing concerns, not the least of which is that there are costs. A systematic process for addressing these competing concerns is essential. Formulation of objectives and evaluation of a policy with respect to these objectives is useful even if one has adopted an analytical approach, such as risk analysis or cost assessment, that addresses only one component of the problem. Awareness that one is ignoring other important concerns at stake may lead to a broader approach to policy.

Policy objectives should satisfy certain well-defined properties.³ The set of objectives should be complete in the sense that all of the impacts of concern with respect to the policy are captured. The objectives also should be operational so that it is possible to obtain values of the policy with respect to each of the objectives. These values need not always be in monetary terms. One can, for example, note that a policy eliminates 1 000 cases of cancer even though one may not wish to attach a price tag to this outcome. The set of objectives should be reasonably limited, but should nevertheless be comprehensive enough to reflect the main matters of interest.

Perhaps the most important practical problem in specifying a well defined set of objectives is that of overlap. Policymakers may, for example, espouse the need for examining the implications of the policy for business costs, competitiveness, productivity, employment, income, and economic growth. These are not independent concerns, and one should avoid multiple counting of such effects so that the net attractiveness of the policy is not distorted.

These properties are often violated in the regulatory guidelines and policy missions specified in regulatory agencies' formal mandates. In the case of risk regulation policies, for example, the mission of the policy is often defined in absolute terms.⁴ Potentially carcinogenic residues must be eliminated to the lowest detectable amounts. Risk levels are mandated to not exceed specific amounts, such as one chance in a million over one's lifetime. Pollution policies must ensure a margin of safety below a zero risk level.
Rigid regulatory missions such as these are more appropriately viewed as regulatory goals rather than as policy objectives. They are well-defined, specific targets for regulation. Ensuring that a particular chemical exposure be at a level of one part per million is a goal, whereas reducing illnesses and deaths from hazardous chemical exposures is a policy objective.

The main difficulty with such regulatory goals is that they often give rise to single-minded concerns. Policymakers focus only on reaching the specified goal rather than on all the diverse effects that a regulation may have, such as impacts on cost or economic growth. Defining a policy in such absolute terms will necessarily prohibit the kinds of trade-offs that one would want within the context of a rational choice reflecting society’s competing interests. Danger signals that one is resorting to the use of an unbalanced approach to policy are apparent when policymakers begin to refer to priority lists and similar kinds of mandates that imply an exclusive concern with one aspect of a policy irrespective of the performance of that policy with respect to other potentially legitimate objectives.

4. BENEFIT-COST ANALYSIS

The most comprehensive form of regulatory analysis is benefit-cost analysis. Under this approach, one calculates the total benefits associated with the regulatory decision, compares these benefits with the total costs, and if the balance is favourable the decision is judged potentially attractive.5

This capsule description of benefit-cost analysis embodies its formal components. However, the rationale for this approach is broader in scope. Essentially, the test is simply that policymakers should select those options that are in society’s interests. Regulatory policies have many effects, both favourable (benefits) and adverse (costs). To undertake a benefit-cost test involves no more than a willingness to ensure that one is achieving a net benefit to society.

The general spirit of the benefit-cost test is that resources are limited, and ideally we should allocate these limited resources in a manner that will maximize the net well-being of society. Economic limits for regulation clearly are consequential. In the United States, for example, there are 94,500 accidental deaths per year. Even if the entire GNP of the United States were devoted to eliminating accidental deaths, the most that could be spent is $35 million per death. Clearly, there must be some stopping point. Identifying decisions that cross that point is the purpose of benefit-cost analysis.

Benefit-cost analysis by itself, however, may not be sufficient for decision-making. For example, when economic resources are limited, one cannot impose all regulations for which benefits are greater than the costs. In such instances, one would impose a more stringent test to ensure that only the most beneficial regulations are adopted.6
Although opposition is sometimes voiced to the use of benefit-cost analysis to identify trade-offs in government decisions, we commonly make such trade-offs in our daily lives. The typical US worker in a hazardous job receives hazard pay of about $500 per year in return for bearing the risk. Elephant handlers at the Philadelphia Zoo, for example, accept $1000 extra per year to face the job risk of being trampled by elephants. Similar trade-offs are present in other contexts. Consumers have switched to smaller and more fuel efficient cars as the price of gasoline has risen. They have done this despite the fact that the US Department of Transportation estimates that there are 1,300 extra deaths per year because people drive smaller cars to decrease their fuel costs.

Although benefit-cost analysis has many attractions, one should be aware of the assumptions embodied in it. Perhaps the most fundamental attribute of the approach is that it should be comprehensive. All policy effects must be considered so that one cannot selectively examine only the desired benefits or partial costs. Impacts on broad societal concerns, such as competitiveness, must be weighed, as should impacts on other government policies. As a general criterion for assessing policy, this aspect of benefit-cost analysis has substantial appeal. Clearly, societies count all important policy effects, both favourable and adverse, as worthy of attention by decision-makers.

**Distributional concerns.** A key assumption frequently included in such analyses is that benefits to one group should be treated symmetrically with losses to others. Thus, if a policy results in one group of citizens incurring costs of $10 million and another group experiencing health benefits worth $20 million, there is a $10 million net gain. This policy will be judged attractive even though different groups bear the costs and reap the benefits. The gainers can potentially compensate the losers, and from that standpoint the policy is efficient. However, unless compensation is actually paid, this justification is not necessarily politically or morally compelling.

The absence of actual compensation does not, however, undermine the potential attractiveness of the benefit-cost approach. Since the bearers of the cost are not compensated, one might choose to place a weight greater than 1.0 on the dollar losses experienced. Moreover, this weight could vary with the particular income group affected. The ability to incorporate such differences indicates that benefit-cost analysis can be carried out so as to account for social preferences concerning distribution of costs and benefits among different groups.

In practice, distinctions between social groups are seldom made. Reliance on the symmetric approach arises in part because of its analytical simplicity. More profoundly, however, distributional concerns usually disappear when one examines the entire portfolio of government policies rather than individual decisions. That some groups may be disadvantaged by a single regulation is not a pressing concern since these groups may benefit disproportionately from other govern-
ment programmes. With a large number of government policies, ideally some mechanism can be found to target benefits to all groups in society so that none will suffer disproportionately overall. For example, income transfer programmes can address concerns of income equity, so that it is not necessary to target all other policy efforts in this manner.

Must everything be quantified? One frequently cited problem with benefit-cost analysis is that not all concerns are readily quantifiable. What, for example, is the value of extending the life of an AIDS victim by five years? Substantial progress has been made in answering such questions for purposes of analysis, but considerable gaps in our knowledge remain.

This does not mean that benefit-cost analysis is unusable in these cases. Even if benefit and cost components cannot be quantified in monetary terms or in any quantitative terms, the benefit-cost approach provides a constructive means for decision-making. Qualitative assessment of benefits and costs – in which policymakers develop a comprehensive tally of policy effects – can be quite useful in helping policymakers to make a judgement that, on balance, the effects on society of the preferred policy are positive. The monetization of policy effects may facilitate the comparison process by establishing a well-ordered metric, but it is not an essential element of the benefit-cost approach.

In situations where monetization is not feasible, it will generally assist the benefit and cost comparison process if one can establish in as quantitative a manner as possible what is at stake. For example, regulatory analysts could note that the policy will prevent 40 severe cases of genetic damage at a cost of $2 million. The question policymakers then ask is whether it is worth $50,000 per case of severe genetic damage to prevent such adverse impacts. Thus, in effect, the analysis monetizes the economic aspects of the policy and permits the judgement of whether the non-monetized benefits are worth the amount expended.

In this example, as well as in other contexts, it is useful to convert unknown values into a single metric. Thus, one can calculate the cost per life saved, the cost per case of cancer prevented, or the cost per case of genetic damage. It will then be possible to have some comparative measure – across regulations and policy areas – of the price being paid in return for what is being achieved.

Other non-monetary metrics are possible. For cases in which there are multiple health effects, it may be possible to establish risk equivalents. For example, we may not be willing to put a dollar value on a case of cancer, but we may be willing to say that a case of cancer should have a value roughly equal to an automobile fatality. The nonquantified health effects could then be converted into a common metric of automobile fatality equivalents. Once we have obtained such measures, we may be able to make a judgement as to whether the policy is attractive.

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These kinds of common metrics have the advantage of allowing policymakers to determine, by comparison with other government decisions and opportunities, whether the costs of a specific regulation are wholly disproportionate to its benefits. Thus, even though we may not be willing to put a price tag on cancer, if we know the cost of prevention is only $50,000 per case, then we may clearly have a sense that the benefit value exceeds this price tag. In contrast, if the cost of prevention is $100 million per case, then in all likelihood one would reject the policy because there would be other regulatory efforts that offer greater gains in return for such expenditures.

**Considering opportunity costs.** This discussion of benefit-cost analysis has stressed such other opportunities because it is the opportunity cost of regulatory policies that drives the rationale for benefit-cost analysis: What is society giving up to achieve these regulatory objectives?

Opportunity costs may be direct in terms of costs imposed on businesses and consumers — resources that could be allocated to other uses. Opportunity costs may also take the form of policies that have been displaced or must be foregone because a particular policy has been adopted. In some cases, these costs come directly out of government revenues so that the budgetary costs are explicit. In other instances, the costs are borne by businesses and one must estimate the costs associated with regulatory compliance. Workers may also bear the costs, as they may lose jobs in response to more costly government regulations, and consumers may pay higher prices for the products affected by regulations as well. The fact that some regulatory costs are internal to the government gives them no special status, even though they may loom large to policymakers.⁹

In all these instances, the objective should be to evaluate costs to all parties and to ensure that the total benefits are in excess of the total costs that are imposed. Benefit-cost analysis simply provides a mechanism for ensuring that this overall balance has been struck.

### 5. COST-EFFECTIVENESS ANALYSIS

A more limited policy tool than benefit-cost analysis is the cost-effectiveness test. Cost-effectiveness measures provide an index of the relative cost to society of various options for promoting a particular objective (usually expressed as cost per unit of benefit). Within the context of risk regulation, for example, the task of this approach is to ascertain which policies minimize the cost of eliminating a given risk.

Cost-effectiveness measures are generally less controversial than benefit-cost tests, because they do not question the wisdom of underlying regulatory objectives. The only regulations eliminated from consideration are those that are clearly less desirable in reaching the desired result — less benefit for more cost —
and hence there will be a broad consensus that the implementation of this test accomplishes a worthwhile objective.

Although cost-effectiveness measures have certain limitations (discussed below) that frequently make them inconclusive with respect to determining the optimal policy, the measures of cost per unit of benefit achieved reflect both beneficial and adverse effects of regulatory policy and provide a useful guide to the relative performance of different policies. Policymakers can use these measures in conjunction with their sense of the value of the objective being promoted to select the regulatory policy. In effect, the implicit benefit-cost test of selecting the policy that best advances social welfare will be made by policymakers, using the cost-effectiveness results as the underpinnings for these judgements.

A critical difference between cost-effectiveness and benefit-cost tests is that, for the former, benefits need not be valued explicitly. The cost-effectiveness measure calculates the cost per unit benefit but does not assign dollar values to outcomes such as equal opportunity, decreased morbidity, or improved nutrition. The data needs for cost-effectiveness tests will consequently be less. The use of this approach often eliminates the difficult task of attempting to value benefit categories explicitly.

**Strengths.** Cost-effectiveness tests are particularly useful in weeding out policy alternatives that are clearly inferior. Suppose that policy A will save 6 lives for $12 million and policy B will save 5 lives for $15 million and that only one of these policies can be pursued. The cost per life saved is $2 million per life for policy A and $3 million for policy B, and the total amount of lives saved under policy A is greater. Policy A consequently has a lower price tag per unit risk and, if such actions are worth pursuing, it offers more risk reduction as well. Policy options that are dominated by superior alternatives can in this way be identified using a cost-effectiveness approach.

**Limitations.** The cost-effectiveness methodology takes as given the desirability of achieving a particular benefit. This is the greatest limitation of the technique. For example, cost-effectiveness analysis was first developed to assess defense expenditures. Generals and other military officials would proudly declare that a particular tank design was the most cost-effective, which simply means the cheapest way to build a tank with these capabilities. Even if such claims are true, it does not mean that society should build the tank, only that we have identified the cheapest way to do so. Given the assumption that the benefits of the policy should be achieved, the task then becomes to find the least costly way to achieve them.

**Using a cost-effectiveness ratio.** As in the case of benefit-cost analysis for which economists have devised benefit-cost ratios, similarly one can calculate cost-effectiveness ratios. In this case, the ratio is the cost per unit of benefit achieved (such as 100 lives saved per $1 million investment).

First, this does not mean that the policy that is greater in the scope of the results is the one that is better or more effective.

Second, ascertaining the promoting factors should be a reduction in much society (in other words explicitly).

Suppose annually from the total budget is no cheap to judge which is.

**Comparison for example.**"
achieved (such as cost per death avoided). This cost-effectiveness ratio is a good measure of the efficacy of the policy, but it is not definitive, for two reasons.

First, the fact that one policy has a lower cost per unit of risk reduction than does another policy does not necessarily mean it is superior. For example, a policy that is more costly per unit of risk reduction may in fact pertain to a much greater amount of risk so that the lower cost-effectiveness is offset by the greater scope of the policy impact. For example: Is it better to save one life for $500 000 or 5 lives for $3 million, where the cost per life saved is $600 000?

Second, as noted, the construction of cost-effectiveness ratios enables one to ascertain the relative performance of the policies in terms of the costliness of promoting particular objectives, but does not resolve the issue of where regulators should stop in terms of incurring costs to promote benefits such as risk reduction. Ultimately, the policymaker must make some judgement about how much society is willing to pay in terms of the cost per unit of any given benefit (in other words, an implicit benefit-cost analysis will be done, even if it is not done explicitly).

Suppose, for example, that there is a policy option that will prevent 2 deaths annually from contaminated drinking water at a cost of $1 billion per life. If there is no cheaper way to prevent these two drinking water deaths, the policy will be judged cost-effective. Yet, it might not be a desirable policy to pursue.

Comparing cost-effectiveness ratios. Cost-effectiveness measures are most beneficial when the government objective is defined broadly enough to allow comparison of many different policy alternatives for reaching it. In risk regulation, for example, comparison of cost-effectiveness measures across policies can highlight ways in which societal resources can be reallocated to save more lives for less money. Thus, comparison of cost-effectiveness rates often provides useful guidance regarding the relative efficacy of policies' performance and profitable opportunities for reallocating resources to maximize their net impact.

To see how one can derive substantial insight into the attractiveness of policies simply by calculating the cost-effectiveness ratios, consider Table 2, which presents cost-effectiveness ratios for a series of US risk regulations. To put the policies in perspective, a value of life of $5 million is used as the threshold for ascertaining whether the regulation would also pass a benefit-cost test. As indicated in the table, the cost per life saved amounts range from $100 000 to $72 billion. Even without ascertaining how far one should proceed in terms of the cost per life saved, simply calculating the cost-effectiveness of the policies enables one to get a good sense of their relative efficacy. Although there can be legitimate debates as to whether the appropriate value of life is $1 million, $3 million, $5 million, or even as high as $10 million, when we see policies with costs per life saved well in excess of $100 million then it is fairly clear that such
Table 2. The cost of various risk-reducing regulation per life saved

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Year and status</th>
<th>Agency</th>
<th>Initial annual risk$^*$</th>
<th>Annual lives saved</th>
<th>Cost per life saved (millions of 1984 $)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rules that pass benefit-cost test:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unvented space heaters</td>
<td>1980 F$^2$</td>
<td>CPSC</td>
<td>2.7 in $10^5$</td>
<td>63 000</td>
<td>.10</td>
</tr>
<tr>
<td>Oil and gas well service</td>
<td>1983 P</td>
<td>OSHA-S</td>
<td>1.1 in $10^3$</td>
<td>50 000</td>
<td>.10</td>
</tr>
<tr>
<td>Cabin fire protection</td>
<td>1985 F</td>
<td>FAA</td>
<td>6.5 in $10^8$</td>
<td>15 000</td>
<td>.20</td>
</tr>
<tr>
<td>Passive restraints/belts</td>
<td>1984 F</td>
<td>NHTSA</td>
<td>9.1 in $10^5$</td>
<td>1 850 000</td>
<td>.30</td>
</tr>
<tr>
<td>Underground construction</td>
<td>1989 F</td>
<td>OSHA-S</td>
<td>2.1 in $10^3$</td>
<td>18 000</td>
<td>.30</td>
</tr>
<tr>
<td>Alcohol and drug control</td>
<td>1985 F</td>
<td>FAA</td>
<td>1.6 in $10^6$</td>
<td>4 200</td>
<td>.50</td>
</tr>
<tr>
<td>Servicing wheel rims</td>
<td>1984 F</td>
<td>OSHA-S</td>
<td>1.4 in $10^5$</td>
<td>2 300</td>
<td>.50</td>
</tr>
<tr>
<td>Seat cushion flammability</td>
<td>1984 F</td>
<td>FAA</td>
<td>1.6 in $10^7$</td>
<td>37 000</td>
<td>.60</td>
</tr>
<tr>
<td>Floor emergency lighting</td>
<td>1984 F</td>
<td>FAA</td>
<td>2.2 in $10^5$</td>
<td>5 000</td>
<td>.70</td>
</tr>
<tr>
<td>Cane suspended personnel platform</td>
<td>1988 F</td>
<td>OSHA-S</td>
<td>1.8 in $10^3$</td>
<td>5 000</td>
<td>.12</td>
</tr>
<tr>
<td>Concrete and masonry construction</td>
<td>1988 F</td>
<td>OSHA-S</td>
<td>1.4 in $10^5$</td>
<td>6 500</td>
<td>1.40</td>
</tr>
<tr>
<td>Hazard communication</td>
<td>1983 F</td>
<td>OSHA-S</td>
<td>4.0 in $10^5$</td>
<td>200 000</td>
<td>1.80</td>
</tr>
<tr>
<td>Benzene/fugitive emissions</td>
<td>1984 F</td>
<td>EPA</td>
<td>2.1 in $10^5$</td>
<td>0.310</td>
<td>2.80</td>
</tr>
<tr>
<td><strong>Rules that fail benefit-cost test:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain dust</td>
<td>1987 F</td>
<td>OSHA-S</td>
<td>2.1 in $10^4$</td>
<td>4 000</td>
<td>5.30</td>
</tr>
<tr>
<td>Radionuclides/uranium mines</td>
<td>1984 F</td>
<td>EPA</td>
<td>1.4 in $10^4$</td>
<td>1 100</td>
<td>6.90</td>
</tr>
<tr>
<td>Benzene</td>
<td>1987 F</td>
<td>OSHA-H</td>
<td>8.8 in $10^4$</td>
<td>3 800</td>
<td>17.10</td>
</tr>
<tr>
<td>Arsenic/glass plant</td>
<td>1986 F</td>
<td>EPA</td>
<td>8.0 in $10^4$</td>
<td>0.110</td>
<td>19.20</td>
</tr>
<tr>
<td>Ethylene oxide</td>
<td>1984 F</td>
<td>OSHA-H</td>
<td>4.4 in $10^5$</td>
<td>2 800</td>
<td>25.60</td>
</tr>
<tr>
<td>Arsenic/copper smelter</td>
<td>1986 F</td>
<td>EPA</td>
<td>9.0 in $10^4$</td>
<td>0.060</td>
<td>26.50</td>
</tr>
<tr>
<td>Uranium mill tailings inactive</td>
<td>1983 F</td>
<td>EPA</td>
<td>4.3 in $10^4$</td>
<td>2 100</td>
<td>27.60</td>
</tr>
<tr>
<td>Uranium mill tailings active</td>
<td>1983 F</td>
<td>EPA</td>
<td>4.3 in $10^4$</td>
<td>2 100</td>
<td>53.00</td>
</tr>
<tr>
<td>Asbestos</td>
<td>1986 F</td>
<td>OSHA-H</td>
<td>6.7 in $10^5$</td>
<td>74 700</td>
<td>89.30</td>
</tr>
<tr>
<td>Asbestos</td>
<td>1989 F</td>
<td>EPA</td>
<td>2.9 in $10^5$</td>
<td>10 000</td>
<td>104.20</td>
</tr>
<tr>
<td>Arsenic/glass manufacturing</td>
<td>1986 R</td>
<td>EPA</td>
<td>3.8 in $10^5$</td>
<td>0.250</td>
<td>142.00</td>
</tr>
<tr>
<td>Benzene/storage</td>
<td>1984 R</td>
<td>EPA</td>
<td>6.0 in $10^7$</td>
<td>0.043</td>
<td>202.00</td>
</tr>
<tr>
<td>Radionuclides/DOE facilities</td>
<td>1984 R</td>
<td>EPA</td>
<td>4.3 in $10^6$</td>
<td>0.001</td>
<td>210.00</td>
</tr>
<tr>
<td>Radionuclides/elem. phosphorus</td>
<td>1984 R</td>
<td>EPA</td>
<td>1.4 in $10^5$</td>
<td>0.046</td>
<td>270.00</td>
</tr>
<tr>
<td>Benzene/ethylenebzo1 styrene</td>
<td>1984 R</td>
<td>EPA</td>
<td>2.0 in $10^6$</td>
<td>0.086</td>
<td>483.00</td>
</tr>
<tr>
<td>Arsenic/low-arsenic copper</td>
<td>1986 R</td>
<td>EPA</td>
<td>2.6 in $10^6$</td>
<td>0.090</td>
<td>746.00</td>
</tr>
<tr>
<td>Benzene/maleic anhydride</td>
<td>1984 R</td>
<td>EPA</td>
<td>1.1 in $10^6$</td>
<td>0.029</td>
<td>820.00</td>
</tr>
<tr>
<td>Land disposal</td>
<td>1988 F</td>
<td>EPA</td>
<td>2.3 in $10^8$</td>
<td>2 250</td>
<td>3 500.00</td>
</tr>
<tr>
<td>EDB</td>
<td>1989 R</td>
<td>OSHA-H</td>
<td>2.5 in $10^4$</td>
<td>0.002</td>
<td>15 600.00</td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>1987 F</td>
<td>OSHA-H</td>
<td>6.8 in $10^7$</td>
<td>0.010</td>
<td>72 000.00</td>
</tr>
</tbody>
</table>

1. Annual deaths per exposed population. An exposed population of $10^3$ is 1 000; $10^4$ is 10 000, etc.
2. P, F, or R = Proposed, rejected, or final rule.


6. COST

Efforts excelled in health and achieved in options with

This approach may not be controversial on one hand, a similar

ratio and the whether it is essentially speci

not specified in policy is with detail on he context of the

Another on costs. Yet it does resources to costs are provided

Costs affected if imposed on regulatory wages they... particularly competitive

Although cost analysis information efforts to determine regulation costly, that is much to whether with the similar relevance...
efforts exceed the bounds of reasonable expenditures to enhance individual
health and safety. The listing in Table 2 indicates that greater gains can be
achieved in terms of lifesaving for far less cost by pursuing the kinds of policy
options with a higher cost-effectiveness.

This approach may appeal to government officials. In some circumstances,
one may not wish to undertake a full-blown benefit-cost test because of the
controversial nature of attaching dollar values to particular benefits. On the other
hand, a simple cost-effectiveness approach may be too limited. An alternative is
this mixed policy approach in which one first calculates the cost-effectiveness
ratio and then compares this ratio with an appropriate reference point to see
whether it is in a reasonable range. In effect, this procedure can be viewed as a
loosely specified benefit-cost analysis where the controversial benefit value is
not specified with precision. Rather, there is simply an effort to ascertain that the
policy is within a reasonable range with respect to such benefit values. More
detail on how such a procedure can be undertaken will be illustrated within the
context of the benefit assessment discussion in Section 7.

6. COST ASSESSMENT

Another approach to policy analysis is to ignore benefits and to focus simply
on costs. This is a partial approach that will not provide comprehensive guidance.
Yet it does provide some index of the extent to which society is committing
resources to a particular regulatory effort. Indeed, it is usually recognition that
costs are potentially consequential and must be evaluated that is the first step
that leads countries to adopt more highly refined types of regulatory analysis.

Costs of regulation may be borne by multiple parties. Tax rates may be
affected if direct government expenditures are involved. Costs may also be
imposed on business and their shareholders. Consumers and workers may bear
regulatory costs that are incorporated in the prices they pay for products and the
wages they receive. In some cases, overall rates of employment may be affected,
particularly by regulations or groups of regulations that affect growth and
competitiveness.

Although tallying the various cost components represents the first step in
cost analysis, in many situations there is an attempt to actually utilize the cost
information to set the level of the regulatory standard. In particular, there is an
effort to determine the technological feasibility and affordability of a regulation. A
regulation is technologically feasible if there are available technologies; however
costly, that can be employed to meet the regulatory standard. Affordability crite-
rria are much more difficult to implement. In some cases, affordability may pertain
to whether all firms or a certain percentage of firms in the industry can comply
with the standard, and this involves judgements regarding not only the level of
the regulatory cost but also the viability of an industry.
Figure 1 illustrates how affordability considerations might enter into setting the stringency of a regulation. As is indicated, as the regulatory stringency increases, cost levels rise. Initially, regulatory costs are relatively flat with respect to the level of stringency, but eventually at stringency level “s” costs escalate as technological limits are encountered. In such a situation, regulators should set the regulation at a level that is near the point “s” at which costs begin to escalate steeply.

![Figure 1. Regulatory costs and the choice of a regulatory standard](image)

An examination of Figure 1 indicates why this policy approach often will yield appropriate outcomes. In the flat section of the cost curve, the marginal cost of providing risk reduction is relatively constant. If the unit benefits of risk reduction are constant as well it will generally be optimal to either pursue regulation up to point “s” where costs begin to escalate or not undertake such efforts at all. At the point “s” where costs increase quite steeply, it may be that very high benefits of regulation would warrant a level of the standard above that at the point where costs begin to escalate. However, errors in the level of stringency selected by setting the standard at point “s”, as opposed to a more stringent level, will be modest.
Unfortunately, Figure 1 illustrates a best case scenario for which examining costs is instructive. In other situations, costs may rise less sharply so that there is a continuum of choices that must be made with respect to how stringent the regulation should be. In such contexts, the errors may be substantial if one only examines costs and not the benefits to society resulting from the regulation.

7. BENEFIT ASSESSMENT

Regulatory analysis that involves more than costs generally entails some kind of benefit assessment. In a fully articulated benefit-cost analysis one would attempt to assign a dollar equivalent to each benefit component. Even approaches that fall short of a benefit-cost test may require some formal benefit assessments.

This is particularly the case when multiple policy effects must be considered in cost-effectiveness analysis, risk analysis, and risk-risk analysis. Ideally, it would be instructive to establish an approach for calculating a single overall index of benefits. For example, if a regulation eliminated 5 deaths and 10 illnesses that were judged to be half as severe as a death, then the policy impact is 10 fatality equivalents. Some form of rudimentary benefit estimation is required to make this bridge.

Valuing benefits. The starting point for any benefit assessment is a review of the general principles guiding benefit values. In all policy contexts, the appropriate benefit value is society's willingness to pay for the outcome. This is not a particularly controversial proposition. Moreover, once benefit assessments are put in this light, the attractiveness of benefit-cost analysis is fairly great.

It is important to correctly value regulatory benefits. Many of the controversies surrounding benefit-cost analysis stem in part from faulty benefit assessments that are not based on society's willingness to pay for the policy outcomes. Rather, highly imperfect surrogates for the benefit values are sometimes used, and these may exclude many important noneconomic benefit components. Such omissions have led critics of benefit-cost analysis to claim that the benefit assessments are incomplete—a criticism that may be appropriate in particular circumstances but does not reflect an inherent limitation of benefit assessments.

Consider the case of valuation of risks to life and health. The first methodology used in this area was that of the human capital approach. In particular, to calculate the value of a human life, analysts assessed the present value of the worker's earnings over his lifetime. This value became the benefit associated with eliminating the risk of a particular death.

This particular valuation approach has one main attribute to recommend it—it is easy to calculate the present value of worker earnings. Moreover, this benefit amount is appropriate in some contexts. For example, in judicial settings where
the issue is the appropriate value of compensation due to the survivors of an accident victim, the present value of worker earnings does serve as a useful measure of the insurance amount. However, while the human capital measure may be a useful measure of compensation, it is not an instructive measure of value from the standpoint of prevention. In fact, the measure is below the appropriate deterrence value by roughly a factor of 10.

The underlying reason is simple. People's lives are worth more than their earnings. Moreover, what is being valued is not the loss of a certain life but rather a small risk to life itself. An individual with lifetime earnings of $1 million may be unwilling to part with $500 000 to prevent a 50 per cent chance of death, but may be quite willing to spend $1 to prevent a one chance in a million of death.

These kinds of attitudes are not inconsistent. Indeed, economic theory predicts that willingness to spend per unit risk reduction should decline as the amount of risk reduction increases. Since most government policies have modest effects on risk levels — typically well below 1/10 000 and more usually in the 1/1 000 000 range — it is appropriate to use valuation amounts that pertain to the valuation of small risk reductions rather than the value of a certain death. This kind of concern brings us back to the underlying principle for benefit assessment — society's willingness to pay for the benefit derived from the policy, which in this case is a small reduction in the risk level.

The main source of economic evidence on risk-dollar trade-offs consists of the wage premiums workers accept for the fatality risks they face on the job. A considerable literature has documented the magnitude of these trade-offs. The economic shorthand that has developed is that by dividing the amount of wage compensation by the size of the risk one obtains a premium per unit risk. When the wage premium is divided by the fatality risk, the resulting figure is the implicit value of a statistical life.

Table 3 summarizes the results of a series of studies of the value of life based on labour market evidence. For a wide variety of countries value of life estimates are typically in excess of $1 million. To put the estimates in more comparable terms, the final column of the table converts these estimates to the value of life that would be pertinent for individuals with the same income level. As the evidence in Table 3 indicates, value-of-life estimates have been obtained not only for the United States, but also for Canada, the United Kingdom, Japan, and Australia. Using a similar methodology, one could also obtain estimates for other countries.

The estimates obtained from labour market studies are willingness-to-accept values. In particular, they measure the compensation required by workers to accept an increase in risk on their jobs. In contrast, policy analyses focus on willingness-to-pay amounts — the amount society is willing to pay for a small
<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Sample</th>
<th>Risk variable</th>
<th>Mean risk</th>
<th>Non-fatal risk included?</th>
<th>Workers' comp included?</th>
<th>Average income level (1990 US$)</th>
<th>Implicit value of life (S million)</th>
<th>Implicit value of life for air travelers (S million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thaler and Rosen (1976)</td>
<td>Survey of Economic Opportunity</td>
<td>Society of Actuaries</td>
<td>0.001</td>
<td>No</td>
<td>No</td>
<td>27,034</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Viscusi (1978, 1979)</td>
<td>Survey of Working Conditions, 1969-1970 (SWC)</td>
<td>BLS, subjective risk of job (SWC)</td>
<td>0.0001</td>
<td>Yes, significant</td>
<td>No</td>
<td>24,834</td>
<td>4.1</td>
<td>5.7</td>
</tr>
<tr>
<td>Viscusi (1981)</td>
<td>Panel Study of Income Dynamics, 1976</td>
<td>BLS</td>
<td>0.0001</td>
<td>Yes, significant</td>
<td>No</td>
<td>17,640</td>
<td>6.5</td>
<td>12.8</td>
</tr>
<tr>
<td>Marin and Psacharopoulos (1982)</td>
<td>UK Office of Population Censuses and Surveys, 1977</td>
<td>Occupational Mortality UK</td>
<td>0.0001</td>
<td>No</td>
<td>No</td>
<td>11,287</td>
<td>2.8</td>
<td>8.1</td>
</tr>
</tbody>
</table>
Table 4. Summary of value of life estimates based on survey evidence

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>Nature of risk</th>
<th>Survey methodology</th>
<th>Average income level</th>
<th>Implicit value of life (S millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jones-Lee (1989)</td>
<td>Motor vehicle accidents</td>
<td>Willingness to pay for risk reduction, UK survey, 1982</td>
<td>n.a.</td>
<td>3.8</td>
</tr>
<tr>
<td>Viscusi, Magat, and Huber (1991)</td>
<td>Automobile accident risks</td>
<td>Interactive computer programme with pairwise auto risk-living cost trade-offs until indifference achieved</td>
<td>43 771</td>
<td>2.7 (median) 9.7 (mean)</td>
</tr>
</tbody>
</table>

Note. All values in December 1990 US dollars.
decrease in risk. For sufficiently small changes in risk, the willingness-to-pay and willingness-to-accept amounts per unit risk should be the same so that the labour market studies will be applicable in other situations as well.

Another technique that can be used to elicit value of benefit estimates is a survey approach in which individuals are asked willingness-to-pay or willingness-to-accept questions pertaining to changes in benefits. The most prevalent methodology used in this area is known as “contingent valuation.” In particular, respondents are asked to value particular market situations, contingent upon the assumption that such markets exist. For example: How much would you be willing to pay for improved traffic safety that reduced your risk of a traffic fatality by 1/100 000 annually, recognizing that this is only a hypothetical thought experiment?

Contingent valuation studies have been undertaken in a number of countries. Table 4 summarizes the results of studies that have valued automobile fatality deaths in the United Kingdom, the United States, and New Zealand. As is evident from the evidence in Table 4, all of the implied value of life figures are in excess of $1 million.

Although surveys represent a more direct approach to ascertaining the value-of-life, the use of surveys is not without its deficiencies. First, the surveys must be designed and administered with substantial care to ensure that respondents give meaningful and thoughtful answers. A well designed survey will also engage the respondent so that he or she gives an honest answer to the question. If the survey respondent believes that the response will influence the policy outcome, there may be an incentive to misrepresent one’s preferences. This strategic problem has not proven to be a major difficulty in practice.  

A third concern is how to incorporate the robustness tests so that the results are not sensitive to the survey methodology. How one asks the questions, whether an iterative bidding scheme is used, whether this bidding scheme moves upward or downward from the initial bid, and similar variations may affect the valuation amount. Because of this, it is important to use a methodology that can be corroborated and gives consistent answers using legitimate variations in approach.

Notwithstanding these limitations, properly designed surveys have the advantage that they can be used to address a wide variety of regulatory benefits that are difficult to quantify. How much is it worth to preserve an endangered species or to prevent a heart attack? Since answers to these types of questions are not available using market data, some method of ascertaining the public’s willingness to pay for these outcomes is essential if dollar values are to be attached to these classes of benefits.
8. DISCOUNTING

Benefit and cost streams for regulatory policies often extend over long periods of time. Cost effects may have a long-term influence, particularly if substantial capital expenditures are involved. Benefits likewise involve long-term effects. Most cancer reduction policies will have an effect that only begins to become apparent in two or three decades. Policies to address climate change likewise will have effects that will not be manifested until the next century. How much should society sacrifice today to generate these future effects? If we have the option of saving lives now or a somewhat larger number of lives in the distant future, which option is preferable?

All of the policy analysis approaches outlined in Table 1 require that policy effects be put on some comparable temporal basis so that some overall judgement can be made. The manner in which effects over time are weighted is known as discounting. Since the relative weights across time may have a pivotal effect on the policy choice, the selection of the discount rate has long been a topic of economic controversy. The source of the debate stems primarily from the substantial stakes involved, not the absence of well-defined economic criteria.

Since benefits that occur in the future have lower present value than those that occur today, one must discount these impacts to reflect this difference. For example, at a 5 per cent real rate of interest, $1 invested today is worth $1.34 ten years from now. Viewed somewhat differently, $1.34 ten years from now has a present value of $1. To treat $1 at any point in time as having the same value is to ignore the potential for productive uses of our resources.

As a practical matter, one should put all benefit and cost values in inflation-adjusted terms so that these benefits can be discounted by a real rate of return. In the United States, the real rate of return on capital has ranged from 1 to 3 per cent in recent years.

Some regulatory agencies have suggested that there should be no discounting at all since what is at risk is not dollars but other impacts such as health and environmental quality. However, what is being discounted is not health impacts but rather society's willingness to pay for these effects. By converting all outcomes into dollar benefit and dollar cost terms, one establishes a metric whereby one can then use a financial rate of discount appropriately.

The failure to discount at all or to treat the discount rate as being zero will lead to clearly undesirable policy implications. Suppose there is a situation where for a $1 cost forever we can prevent all cases of cancer likely to occur in the world this year. If the discount rate were zero, one would not undertake this policy because any cost of infinite duration is infinite and will outweigh any present payoff, irrespective of how great it may be.
As a general rule, discounting at higher rates will decrease the value of deferred payoffs so that policies with longer term benefits relative to costs will tend to look less attractive. High rates of discount will tend to favour policies that are less capital intensive and which provide more immediate benefits. Use of a lower discount rate will make us more future-oriented and more concerned with issues such as climate change, global warming, and the prevention of cancer – outcomes which occur with a substantial lag.

9. **RISK ASSESSMENT**

A key element of any policy analysis of a regulation intended to reduce risks to human health or safety or the environment is determination of the magnitude of the risk being addressed. Are the risks of consequence? How much does the policy reduce the risk? Obtaining some assessment of the degree to which policy improves the health and safety of those whom it is trying to protect is clearly of concern irrespective of whatever the policy objective is.

Risk analysis focuses on only one aspect of policy effects—the risks that will be reduced. Unlike benefit-cost or cost-effectiveness analysis, there is no assessment of the costs incurred to achieve the risk reduction. Similarly, there is no requirement that there be a tallying of all benefit and cost components and a balancing of societal interests, as under benefit-cost analysis. Thus, risk analysis is more limited in scope than either of these other policy approaches.

Nevertheless, risk analysis is important both as an essential component for more comprehensive policy evaluation and as a decision-making test in its own right. Almost every health and safety regulatory policy has some laudable objective. However, it is essential to know whether these efforts are having a negligible effect on risks or whether we are truly making substantial progress.

As our scientific understanding increases and our ability to measure infinitesimal levels of risk becomes refined, there will be an increasing number of opportunities for influencing risk, but many of these efforts will generate trivial gains. Society clearly should attempt to select those policies that will do the most good. Since risk analysis does not involve any assessment of costs or risk-money trade-offs, there should be broad support for this technique as a vital means of promoting policies that truly improve the quality of life.

The need to put risks in perspective also arises because of the multiplicity of risks we face and that will remain even under a vigorous regulatory regime. Table 5 summarizes a variety of risks faced in our daily life that pose an annual death risk of one chance in a million. We could incur risk of this magnitude by travelling ten minutes by bicycle, having a chest X-ray in a good hospital, or eating 100 grilled steaks.
**Table 5. Risks that increase the annual death risk by one in a million**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Cause of death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking 1.4 cigarettes</td>
<td>Cancer, heart disease</td>
</tr>
<tr>
<td>Drinking 0.5 liter of wine</td>
<td>Cirrhosis of the liver</td>
</tr>
<tr>
<td>Spending 1 hour in a coal mine</td>
<td>Black lung disease</td>
</tr>
<tr>
<td>Spending 3 hours in a coal mine</td>
<td>Accident</td>
</tr>
<tr>
<td>Living 2 days in New York or Boston</td>
<td>Air pollution</td>
</tr>
<tr>
<td>Travelling 6 minutes by canoe</td>
<td>Accident</td>
</tr>
<tr>
<td>Travelling 10 miles by bicycle</td>
<td>Accident</td>
</tr>
<tr>
<td>Travelling 150 miles by car</td>
<td>Accident</td>
</tr>
<tr>
<td>Fying 1 000 miles by jet</td>
<td>Cancer caused by cosmic radiation</td>
</tr>
<tr>
<td>Fying 6 000 miles by jet</td>
<td>Cancer caused by cosmic radiation</td>
</tr>
<tr>
<td>Living 2 months in Denver on vacation</td>
<td>Cancer caused by natural radioactivity</td>
</tr>
<tr>
<td>Living 2 months in average stone or brick building</td>
<td></td>
</tr>
<tr>
<td>One chest x-ray taken in a good hospital</td>
<td>Cancer caused by radiation</td>
</tr>
<tr>
<td>Living 2 months with a cigarette smoker</td>
<td>Cancer, heart disease</td>
</tr>
<tr>
<td>Eating 40 tablespoons of peanut butter</td>
<td>Liver cancer caused by aflatoxin B</td>
</tr>
<tr>
<td>Drinking Miami drinking water for 1 year</td>
<td>Cancer caused by chloroform</td>
</tr>
<tr>
<td>Drinking 30 12-oz. cans of diet soda</td>
<td>Cancer caused by saccharin</td>
</tr>
<tr>
<td>Living 5 years at site boundary of a nuclear power plant in the open</td>
<td>Cancer caused by radiation</td>
</tr>
<tr>
<td>Drinking 1 000 24-oz. soft drinks from banned plastic bottles</td>
<td>Cancer from acrylonitrile monomer</td>
</tr>
<tr>
<td>Living 20 years near PVC plant</td>
<td>Cancer caused by vinyl chloride (1976 standard)</td>
</tr>
<tr>
<td>Living 150 years within 20 miles of a nuclear power plant</td>
<td>Cancer caused by radiation</td>
</tr>
<tr>
<td>Eating 100 charcoal-broiled steaks</td>
<td>Cancer from benzopyrene</td>
</tr>
<tr>
<td>Risk of accident by living within 5 miles of a nuclear reactor for 50 years</td>
<td>Cancer caused by radiation</td>
</tr>
</tbody>
</table>


Clearly, we face risks from all the diverse activities and products in our lives. Ideally, society should target its resources to achieve the greatest risk reduction in return for our efforts. Statistics such as those in Table 5 should not lull us into a false sense of precision, however, concerning the accuracy of the risk assessments. There is typically a range of uncertainty, often quite considerable, around these risk values.
Table 6. \textit{Risks and their uncertainty}

<table>
<thead>
<tr>
<th>Action</th>
<th>Annual risk</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle accident (total)</td>
<td>$2.4 \times 10^4$</td>
<td>10%</td>
</tr>
<tr>
<td>Motor vehicle accident (pedestrian only)</td>
<td>$4.2 \times 10^5$</td>
<td>10%</td>
</tr>
<tr>
<td>Home accidents</td>
<td>$1.1 \times 10^4$</td>
<td>5%</td>
</tr>
<tr>
<td>Electrocution</td>
<td>$5.3 \times 10^6$</td>
<td>5%</td>
</tr>
<tr>
<td>Air pollution, eastern United States</td>
<td>$2.0 \times 10^4$</td>
<td>Factor of 20 downward only</td>
</tr>
<tr>
<td>Cigarette smoking, one pack per day</td>
<td>$3.6 \times 10^3$</td>
<td>Factor of 3</td>
</tr>
<tr>
<td>Sea-level background radiation (except radon)</td>
<td>$2.0 \times 10^5$</td>
<td>Factor of 3</td>
</tr>
<tr>
<td>All cancers</td>
<td>$2.8 \times 10^3$</td>
<td>10%</td>
</tr>
<tr>
<td>Four tablespoons peanut butter per day</td>
<td>$8.0 \times 10^4$</td>
<td>Factor of 3</td>
</tr>
<tr>
<td>Drinking water with EPA limit of chloroform</td>
<td>$6.0 \times 10^7$</td>
<td>Factor of 10</td>
</tr>
<tr>
<td>Drinking water with EPA limit of trichloroethylene</td>
<td>$2.0 \times 10^9$</td>
<td>Factor of 10</td>
</tr>
<tr>
<td>Alcohol, light drinker</td>
<td>$2.0 \times 10^5$</td>
<td>Factor of 10</td>
</tr>
<tr>
<td>Police killed in line of duty (total)</td>
<td>$2.2 \times 10^4$</td>
<td>20%</td>
</tr>
<tr>
<td>Police killed in line of duty (by felons)</td>
<td>$1.3 \times 10^4$</td>
<td>10%</td>
</tr>
<tr>
<td>Frequent flying professor</td>
<td>$5.0 \times 10^5$</td>
<td>50%</td>
</tr>
<tr>
<td>Mountaineering (mountaineers)</td>
<td>$6.0 \times 10^4$</td>
<td>50%</td>
</tr>
</tbody>
</table>


Table 6 summarizes a variety of different kinds of risks and the degree of uncertainty associated with them. Many risks are known with substantial precision. The annual risk of being killed in a motor vehicle accident or in a home accident is reasonably well known in large part because the events are readily observable, and they occur with substantial frequency. In contrast, other risks are less precisely understood, such as the risks associated with air pollution, cigarette smoking, drinking water, and chemicals such as trichloroethylene. In these instances the degree of uncertainty may be quite broad.

Using expected benefits. Risk assessment offers many alternative methods of estimating risk. If the goal is to save the greatest expected number of lives, the focal point of policy analysis should be the “mean” risk level, which indicates the results that are most likely to occur. This approach will save more lives on average than if we become excessively concerned with worst case scenarios that have a low probability of occurrence.

Two examples will clarify the notion. First, suppose that regulators face a regulatory decision between two policies of equal cost. The first policy is expected to save 5 lives, and this figure can be estimated quite precisely based on past evidence but the number is several as small as zero in this case, the saving will be saved.

The second policy may be as large as 8 (proportion), but the same as for the first policy, as it is always difficult to determine the outcome.

Death is the mean, and the makers not only 50 people to refine.

The rounded interval of uncertainty is between an interval of 10, but it falls in the interval of 50, 8 (proportion), and the risk level of the aspect of uncertainty is not with refined precision.

Pricing United States, the confidence interval of expected value of life using the argument would be increased from 1 to 10, one will be met.

The risk of focusing on ourselves, aversion...
on past experience with the risk. The second policy is expected to save 6 lives, but the number of lives saved is less well understood – the policy could save as few as zero or as many as 12 lives (probabilities are uniformly distributed). In this case, the uncertain policy is preferable since a greater expected number of lives will be saved.

The second example illustrates a mistake commonly made by regulators. If the choice is between saving 5 lives with substantial precision, or an uncertain policy that is expected to save 4 lives, but could save as few as zero or as many as 8 (probabilities are uniformly distributed), then the well-understood policy that is expected to save 5 lives is preferable. The uncertain policy might save as many as 8 lives, but the expected lives saved are fewer. Policy-makers should always demand to see the expected results, not only the possible range of outcomes.

Dealing with uncertainty. Although the primary matter of concern should be the mean risk, it is useful to understand the precision of our knowledge. Policy-makers may well find it important to know if an outcome is 90 per cent likely, or only 50 per cent. Estimating uncertainty also highlights the areas where it is useful to refine the information base to obtain a better understanding of the risk.

There are a variety of ways in which one can express the uncertainty surrounding these risk assessments. One is to establish a 95 per cent confidence interval that will characterize the distribution of the risk. There will be a 95 per cent chance that the risk level falls within this interval, a 2.5 per cent chance that it falls above it, and a 2.5 per cent chance that it falls below it. Establishing intervals of this type is a useful mechanism for establishing the range of uncertainty, but in terms of a policy guide the appropriate value should be the expected risk level. In particular, the mean risk value is most important, not some other aspect of the distribution. A broad confidence interval simply means that the risk is not well understood (an important piece of information for policy-makers).

Practices to avoid. One common, and unfortunate, practice in the United States regulatory context is to focus on the upper end of the 95 per cent confidence interval in setting standards. In effect, the emphasis is on the risk value that will only be exceeded 2.5 per cent of the time. The justification for using the upper end of the 95 per cent confidence interval is frequently based on arguments of conservatism. By relying on an overstatement of the actual risk level, one will adopt policies that are more stringent than would be the case if we used the mean as our guide.

There is no analytical justification for such conservative biases. In effect, by focusing on the upper end of the 95 percent confidence interval we are lying to ourselves about what the true risk level is. One cannot use the argument of risk aversion to justify such an emphasis. Risk aversion requires that we value the
payoffs associated with risks appropriately, not that we distort these risks in the course of our analysis.

The dangers of using the upper end of the 95 per cent confidence interval are similar to failing to use the expected value, as is apparent in the following example. Suppose that the government can address one of two possible sources of air pollution. Source A leads to 5 expected deaths per year, but our knowledge of the properties of this chemical are very imprecise. As a result, the upper end of the 95 per cent confidence interval indicates that we might possibly be saving 20 lives per year by regulating this chemical, though we do not know for sure. In contrast, chemical B poses a risk that leads to an average of 10 deaths per year, and we know this risk level with precision.

Suppose that there are budgetary constraints that necessitate focusing on only one of the two chemicals. Is it better to regulate chemical A or chemical B? In this instance, twice as many lives will be saved on average by regulating chemical B. Focusing on chemical A because of emphasis on a possible worst case scenario in effect sacrifices five expected lives. Likewise, regulatory policies intended to be more protective, by treating chemicals as more dangerous than they likely are, will end by saving fewer lives, because governments will focus too much attention on the wrong risks.

Other kinds of biases undertaken in the name of conservatism or higher protection often creep into analyses as well. Risk estimates may be multiplied by arbitrary factors such as 2, 10, or 100. Similarly, some policies seek to reduce the risk to some factor much smaller than the zero risk level, e.g., one-tenth of the exposure level associated with positive risk amounts. These distortions likewise have no analytical justification and only serve to distort the actual risk level.

Attempts to reduce risk exposure levels below the zero risk exposure amount are often characterized as providing a "margin of safety." However, it should be realized that once the zero risk level has been achieved, these additional margins of safety are costly and do not save additional lives. It may be that these safety margins are a legitimate reflection of public concerns. However, if the public were given a choice to reallocate resources from providing a margin of safety without influencing expected health status to policies that were genuinely expected to save lives, it is likely that the policy emphasis on safety margins would diminish.

In some instances, potential errors in risk assessment can be traced to the underlying scientific models used. Assessing the risks to humans based on the risks to the most sensitive animal species is another manifestation of the conservatism bias. Typically scientific evidence is available on a variety of animal species from which one can extrapolate to humans. Ideally, regulatory agencies should utilize all of the information available to make the best estimates of the risks to proven.

The last, but not least, is the possibility of warming losses that farmers would bear in the short term, which is likely to be somewhat small relative to other considerations.

Ri is imp (harm) should sound of risk and a cost—assess the risk.
risks to humans as opposed to simply focusing on the species that has been proven to be most sensitive to the risk exposure.\textsuperscript{16}

There are a variety of other pitfalls one should avoid in risk analysis. Analysts, for example, sometimes assume that industrial pollution takes place with facilities operating at full capacity, whereas in practice less than full capacity may be the typical operating practice. Similarly, there is seldom recognition of the possibility of an adaptive response. Much of the controversy over greenhouse warming stems from the fact that scientists who have projected the substantial losses associated with climate change have failed to take into account societal adaptation to changes in climatic conditions. One would, for example, expect farmers to alter the crops they grow and to alter their irrigation practices so that the losses would be diminished as compared with a situation in which there is no change in behaviour. Change, however, is not costless and these adjustments may be incomplete. The possibility of adaptation does not in any way imply that the risks are necessarily small, only that failure to account for the adaptation in all likelihood will lead to overestimation of the risks.

**Risk management: a separate decision.** When undertaking an assessment, it is important not to confuse risk assessment (calculation of the probability of harm) with risk management (strategies for reducing the risk). Risk assessment should be an entirely separate process from the task of making policy decisions. A sound risk assessment is necessary irrespective of whether the ultimate objective of risk assessment is to incorporate it within the context of a benefit-cost analysis, a cost-effectiveness analysis, or simply an examination of the risk to see whether it is important given the mandate of the regulatory agency. The purpose of risk assessment is simple – to ascertain the degree to which the regulation will alter the risks and improve public health and safety.

10. **RISK-RISK ANALYSIS**

A variant on risk analysis is known as risk-risk analysis. Under this approach, one does not simply calculate the direct effects of the regulation on risk. Rather, one attempts to assess whether other risks may also be affected and to determine whether, on balance, the net effect of the regulation on risks is beneficial. Thus, the methodology is identical to risk analysis. The only difference is that the domain of inquiry is not limited to factors traced directly to the influence of the regulation. Risk-risk analysis arose largely from concerns that some risk regulations actually increased rather than reduced total risks.

There are two principal ways in which there could be other risk effects. The first mechanism is that the regulation may lead to a risk trade-off in terms of either a behavioural response to the regulation or through the multiplicity of risks that may be influenced by it. The following examples illustrate how this linkage
can occur. Regulatory officials occasionally consider bans of artificial sweeteners of various kinds. In the United States, for example, cyclamates have been banned, and saccharin must bear a hazard warning label. Bans and other acts that discourage the use of artificial sweeteners can cause other risks if consumers then eat food higher in calories. This may expose them to greater risks of heart disease and cancer that may offset, at least in part, the beneficial effects of limiting the use of artificial sweeteners.

A more mundane example of the presence of risk-risk trade-offs is that of drinking water. Chlorination of drinking water poses some cancer risk, though it is believed to be very small. Eliminating the use of chlorine would, however, lead to the risk of other illnesses caused by the bacteria that would be found in untreated water. Thus, policymakers ultimately have made the judgement that the risk reduction achieved through the use of the chlorine is greater than the cancer risk of that chemical. In a similar vein, there are adverse reactions to many widely used vaccines, such as the DPT vaccine. There is consequently a trade-off in terms of the decrease in diseases that will be prevented by the use of vaccines against the risks of adverse reactions, some of which may be fatal.

A more subtle kind of trade-off occurs when a regulation has spillover effects on a quite different type of risk. Fuel economy standards designed to promote the production of smaller and more fuel efficient cars will decrease the health risks associated with energy-related environmental pollution. However, it does this at a greater risk to the passengers themselves, who are more likely to die in accidents.

Determining whether, on balance, risk levels are increased or decreased is not always a straightforward process. If risks are of the same type (e.g. fatalities), then it is a simple matter to determine whether deaths rise or fall as a result of the policy. However, if there is a trade-off that involves different kinds of health outcomes, such as the risk of cancer from artificial sweeteners against the risk of heart disease from obesity, then some method is needed to determine the relationship between society's value of these risks. Nevertheless, an assessment of the magnitudes of the effects is an important prerequisite to any subsequent analysis and is a useful first step in highlighting how the regulation influences risk policy outcomes.

**Risk-risk trade-offs and regulatory costs.** The most recent variant of risk-risk analysis, and one that has received substantial prominence in the United States, is the effect of regulatory expenditures on risks. All regulations involve some kind of costs, and these costs will make society economically poorer overall. In some cases, these costs are borne by shareholders of the companies affected. In others, it may be that workers' wages will be adversely affected by regulatory costs or the prices paid by consumers will reflect these costs. Finally, it may be that the taxes of society at large are raised to fund the cost of a regulation. In all of
these cases, there will be cost effects and real opportunity costs to society of the regulatory policy.

These costs are consequential, not simply because of benefit-cost concerns, but because of risk-related concerns as well. In particular, studies indicate that there is a strong positive income elasticity of individual health. As societal incomes rise, health status improves. Moreover, within countries, higher income groups generally have better health insurance, are more likely to take health-enhancing actions such as exercise, and have greater longevity. By making society poorer, regulatory costs consequently have some influence on health status as well since they decrease the resources society has available for various expenditures, including those that enhance individual health.

One mechanism for determining the extent of the relationship is to estimate how responsive mortality rates are to changes in income. How much of a drop in societal income is necessary to lead to one statistical death? Although there are a wide range of estimates for this relationship, one widely cited study indicates that the appropriate value is $12 million (in 1991 prices). This estimate implies that for every $12 million in regulatory expenditures there is a loss of one statistical life, because the beneficial effect of income on health will no longer be able to take place once income levels have been diminished.

An alternative methodology for determining the level of regulatory cost that leads to one statistical death is based on a linkage between estimated value of life figures and this amount. In particular, the amount of regulatory expenditure that leads to the loss of one statistical life equals the estimated value of life divided by the marginal propensity to spend on health. My estimates for 24 OECD countries indicate that the marginal propensity to spend on health out of income is 0.1. As a result, to determine the regulatory cost that will lead to one statistical death one simply multiplies the estimated value of life by a factor of 10. For example, if in a particular country the pertinent value of life estimate is $3 million, then $30 million in regulatory expenditures will lead to the loss of one life. Other value-of-life estimates can be used similarly.

Although this methodology is still being refined, it is useful in that it highlights the fact that – even if one is not directly concerned with cost-risk trade-offs as in the case of benefit-cost analysis and cost-effectiveness analysis – regulatory costs still are a matter of concern. In particular, these costs also have risk consequences so that even if one’s sole concern is with risk levels one cannot completely ignore the cost impacts of regulatory policies.

The exact components of this risk-risk approach are still being refined, as it remains fairly new. Nevertheless, it promises to be a major addition to the regulatory analysis alternatives since it provides a more comprehensive perspec-
tive on the risk consequences of regulation without having to engage in the difficult process of assessing what the appropriate risk-cost trade-off should be.

11. THE IMPORTANCE OF REGULATORY IMPACT ASSESSMENTS

The overriding purpose of obtaining an assessment of the merits of regulatory policies is to ensure that they have a sound foundation in economic and social realities. Most importantly, is society obtaining sufficient benefits from these policies to justify the costs that are being imposed? Since these costs are frequently not budgetary costs but instead are borne by third parties, policymakers are usually less aware of these costs than if they were dealing with an expenditure programme.

As the costs imposed by regulation continue to escalate, the need for more refined regulatory analyses will increase. Much of the impetus for the increased reliance on analytical judgements is the recognition that the costs of regulation are becoming truly substantial – running into the hundreds of billions of dollars. Some mechanism must be found to ensure that society is obtaining as much benefit as it can from these expenditures. Economic analysis of regulatory effects can be viewed as the framework for providing the substantive basis for making these policy judgements.
NOTES

1. W. Kip Viscusi is the John F. Cogan Jr. Professor of Law and Economics and Director of the Program of Empirical Legal Studies at the Harvard University Law School and is a specialist in regulatory analysis including risk assessment and regulatory impact analysis.

2. Thus, the general task is to maximize some social welfare function $W(X_1, X_2, ..., X_n)$, where the $X_i$ are the different objectives. In general terms, policy objectives are similar to attributes of consumer choice. One should always prefer more of the objective to less, or possibly less of the objective to more, as in the case of costs. The objective should be a well ordered metric so that option A is either preferred to option B, is indifferent to B, or is less preferred to B in terms of the degree to which it promotes a particular objective. Finally, the objective should be transitive. If option A provides more of a particular objective than does option B, and option B provides more of that objective than does option C, then the value of that objective achieved through option A exceeds that of option C.

3. For a review of the general approach to benefit-cost analysis and the formulation objectives, see Stokey and Zeckhauser (1978).

4. Economists will recognize these preferences as lexicographic orderings.

5. A corollary to the benefit-cost test is that since the objective is to maximize the spread between benefits and costs, one should continue to increase the scale of the policy until the point where the marginal benefits equal the marginal costs. Thus, in the case of tightening of risk regulation one would impose increasingly stringent standards on health risk exposures until marginal costs are no longer below marginal benefits.

6. In particular, one would maximize $B - 1C$, where $B$ represents benefits, 1 is the shadow price of capital, and $C$ is the total cost of the policy. Higher values of 1 are associated with tighter budgetary constraints, where 11 if budgets are constraining. In terms of a practical guide to decision, in the case of budgetary constraints with continuously divisible policies, one would adopt policies with a ratio of $B/C$ until this ratio just equalled the shadow price of capital 1.

7. Underlying this procedure is the Kaldor-Hicks potential Pareto compensation principle.

8. Indeed, we might even wish to argue that a case of cancer is more valuable in terms of the degree of loss than an automobile fatality. If we were willing to make some assessment as to the relative value, such as being 1.5 times the loss, then an assumption such as this could be incorporated into the analysis just as easily.
9. One refinement that should be noted is that the shadow price for government resources may differ. If, for example, budgetary constraints lead the government to adopt only projects with a benefit-cost ratio of 1, where $I > 1$, and if all policies are perfectly divisible, then the weight on the government costs should be 1. These costs have a higher opportunity cost since each dollar in expenditures can produce 1 in benefits.

10. The main reason why all these studies have utilized labour market data is that there are good data available on workers and their jobs that make it possible to disentangle the premium for risk from compensation for other attributes of the job. Such an estimation is a nontrivial task since more affluent workers tend to prefer safer jobs. One must consequently isolate the incremental premium workers receive for risk. For a more complete description, see Viscusi (1992a).

11. The reference point used is the average income of air travellers in the United States, which is higher than average US income, overall. In addition, the extrapolation was based on an assumed income elasticity of the value of life of 1.0. This estimate is based on the findings in Viscusi and Evans (1990) for non fatal job injuries.

12. An interim approach that can also be used is to adjust the value-of-life estimates that have been obtained in other countries to take into account the income differences and use this estimate as the value of life for the purposes of policy analyses.

13. It can be overcome through appropriate design of the survey by, for example, asking whether the respondent would be willing to vote for a particular initiative. Once placed in the median voter context, there is no incentive to misrepresent one’s tastes.

14. There are exceptions if there are sign reversals in the time stream of net benefits-costs. Complex patterns of uncertainty over time can also lead to reversals.

15. Risk assessment is principally used for policies aimed at reducing risks to human health and safety and environment, but could be applied to any regulatory decision whose need or effect depended on the probability of a specific outcome.

16. There are other types of scientific concerns as well. For example, emphasis on a one-hit linear model as opposed to a multi-hit model or a non linear model of the risk may create biases in the risk assessment process.

17. See the letter from James B. MacRae, Jr., Acting Administrator, Office of Information and Regulatory Affairs, US Office of Management and Budget to Nancy Risque-Rohrbach, Assistant Secretary for Policy, US Department of Labour, March 10, 1992. See also statement of James B. MacRae, Jr. before the Senate Committee on Governmental Affairs, March 19, 1992. More generally, see Lutter and Morrall (1992).

18. This updating is done by the author using the results reported by Keeney (1990).

19. This approach is developed in Viscusi (1992b).
REFERENCES


