DRAFT FOR COMMENTS

APPROACHES TO RISK IN PUBLIC MANAGEMENT

Rod Dobell and Ted Parson

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1) Introduction:

Problems of risk and risk management (1) are increasingly prominent in contemporary public policy debate. Indeed, although significant controversy inevitably surrounds many aspects of proposed new initiatives -- economic impact, distributive impact, environmental impact, and foreign relations, as well as risks to life and health -- public debate on many issues seems to be coming more and more to focus on the estimation of the risks that people will face, and the determination of an acceptable level of risk in each context. For evidence of this, one need only look at news coverage of energy policy (how safe is nuclear power?), the chemical industry (what health risks do we face from all the new untested chemicals?), licensing of drugs and birth control devices (How much must they be tested before release?), forestry (How much spraying is acceptable?), and new office technology (what are the radiation and health effects of CRTs?).

There is another debate, as prominent as those over particular sources of risk, over what the best means are for making public decisions on matters of risk. This second debate focuses principally on the merits (or lack thereof) of a set of analytical techniques for risk decision-making, known as Risk-Benefit Analysis or Quantitative Risk Assessment. These techniques have been both praised as the definitive answer to risk decisions (2), and attacked as autocratic, misleading, and dangerous. (3) We contend that neither of these views is correct; these techniques, which we will refer to as Risk-Benefit Analysis or RBA, can only be evaluated by

comparing them to the other approaches to decision-making with which they compete. When compared on these terms, RBA comes out rather well, although the valid criticisms directed against it point out the necessity for certain caveats in its use. For the practising public administrator, we have three messages. You should be conversant with these techniques. If the attacks levelled against them have led you to dismiss them, you should reconsider. But because they have major weaknesses, you should be prepared to be a cautious and critical client. This present paper thus is intended as a brief survey of a rapidly growing literature -- a review article designed to bring to the attention of public servants (and those who teach aspiring public servants) some possible sources of guidance in an increasingly controversial area.

Does the public servant need to be concerned with matters of risk at all? We answer yes -- trivially yes in a sense, for the world is uncertain and every decision involves some risk. Consequently, any significant public policy decision will have risks among its effects. But beyond the riskiness inherent in any decisions, there are particular reasons that public servants are likely to have to make decisions imposing risks on the public.

Risk controversies usually pit one social group against another. The most common direction of conflict is between commercial interests who wish to engage in risky activity for profit, arguing that the risks are sufficiently small, and consumer, labour, or 'public interest' groups who wish to restrict the activity, arguing that the risks are too great. Other directions of conflict are possible: one group of consumers willing to take the risks associated with a new or existing product versus another wishing to see it restricted (birth control devices, licensing of prescription drugs), or an identifiable group whose rights are reduced by measures intended to increase the safety of some general public versus the government as agents of the public (pilots or AIDS victims facing compulsory reporting of their medical records).

Whenever an issue of risk involves such an inter-group conflict, there is likely a public servant caught in the middle. As regulator of industrial and commercial activity, the public servant must balance the claims of business, labour, consumer, and public interest groups in setting standards for product safety, occupational health, and environmental quality. As the provider of services to protect the public-- such as police and fire protection, sewage treatment, and public health-- the public servant must balance increased protection of the public against increased expenditure of the public's limited funds. And in many other decisions that fall to the public sector -- decisions on such matters as energy supply, criminal justice, and foreign policy -- risk is one significant factor that must be weighed.

Consequently, the conduct of the public servant, whether engaged in policy advice or programme administration, is inextricably bound up with matters of public risk. Some public servants may have the good fortune to escape the necessity to make such choices, but most can not avoid taking risks with the public. This is true in small decisions and large, and at both the political and the administrative levels. If imposing risks on the public cannot be avoided, what help can be offered in discharging this duty responsibly?

2) The Analytic Approach to Risk Decisions.

Much debate on risk in public policy focuses on the use of Risk-Benefit Analysis (RBA), an analytic technique with its roots in the methodology of Cost-Benefit Analysis (CBA). The current government environment, in which the need for objective evaluation of programmes and the demonstration of their merit is emphasized, is one in which such techniques as CBA and RBA are bound to be attractive; they purport to provide objective, defensible measures of the net

social benefits associated with particular programmes and policies, and so can provide compelling support for decisions.

In a Cost-Benefit Analysis, one lists all the major identifiable consequences of a decision and assigns values to the costs or benefits associated with each. These figures are then combined to yield a single figure -- either a difference or a ration -- that describes the total net social benefit of the decision. CBA is similar to the accounting techniques used in private business to estimate the expected profitability of investment opportunities, but differs from them in two important respects. First, benefits and costs to all affected people must be counted, so positive and negative externalities are included. Second, because the total social benefits resulting from the provision of a good or service will generally exceed the revenue from the sale of the product and aggregate social costs will often differ from recorded costs, consumer's and producer's surplus concepts must be used rather than simple revenue and cost estimates.

These two adjustments, to reflect both the broader constituency and more general social valuations, can shift the result in either direction from that which would be obtained by a private agent's assessment of costs and benefits; a project which would be highly profitable for a private operator could be rejected by a public cost-benefit analysis if it achieved its profitability by imposing on the community high external costs for waste disposal or through reduction of environmental quality, for example, while a transportation project which would not be profitable for a private operator might nevertheless provide a level of (unpriced) public benefits high enough to justify its cost. One possible illustration would be a bridge with a high fixed cost and a declining average cost structure.

The estimation of costs and benefits can be very difficult. This is the case for goods of obvious value for which there is no market, such as transportation on public roads. Even more

problematic is the determination of the value of external effects such as visual impacts, noise, and pollution. For a thorough introductory treatment of the valuation of such costs and benefits, the interested reader is referred to Mishan (4) or Dasgupta and Pearce (5).

Risk-Benefit Analysis uses the same methods as CBA, but expands the treatment to include a probabilistic description of risks resulting from a decision. The risk of a particular event is defined as the product of its probability of occurring and the consequences of its occurring; a 1% chance of losing a million dollars is defined as a risk of .01 x $1,000,000 or $10,000. A 50% chance of losing $20,000 also represents a risk of $10,000. The total risk associated with a decision is the sum of all risks associated with all possible consequences of the decisions. The process of RBA thus adds three stages to a CBA: enumerating all of the uncertain undesirable consequences of a decision, assigning measures of probability and consequence to each, and adding them up to estimate an "expected" value.

Both the probabilities and the consequences used in a RBA must usually be estimated. The precision of the estimates varies widely from problem to problem. The most precise estimates of probabilities are available for issues such as highway safety; one might, for example, from empirically observed relative frequencies, be able to state with high confidence that a particular expenditure on highway improvement could be expected to result in the saving of, say, two lives per year on average. Much less precise estimates of probabilities are available in the consideration of new technologies such as nuclear power or liquified natural gas (LNG), that have a small probability of causing catastrophic losses. In estimating just how small the probability is, one can not use historical data on the operation of these facilities, because there is not enough such data available (life is not long enough to generate the relevant experience), and

because the probability of a major accident at a particular plant depends on the particular design details of that plant (each case is different).

To obtain probability estimates in these difficult cases, a technique known as fault-tree analysis is used. One bargains by hypothetically assuming that a major accident has happened, and reasons backwards, asking what events must occur in order for the accident to happen, and what prior events in turn must occur for these events to happen. This backwards reasoning is represented by a tree, with the final accident at the trunk, and the successively simpler prior events and logical relations between them represented by the smaller upper branches. Through this technique, the unknown probability of a particular kind of major accident can be expressed in terms of a large number of simpler probabilities of such events as valves sticking, tanks rupturing, or pumps failing. These simpler probabilities can be estimated by reference to a much larger body of historical operating experience with similar components. For an introductory treatment of fault-tree analysis, the reader is referred to McCormick (6) or Rasmussen (7).

The estimation of consequences of events also ranges from fairly easy to enormously difficult. For common events such as automobile accidents, fires, or explosions of a specified magnitude, historical data can be used to estimate loss of life and property damage with reasonable accuracy; but risk-benefit studies must often estimate the consequences of such events as exposure to substances of potential toxicity, carcinogenicity, or mutagenicity, and this estimation is very difficult. Testing for these properties is slow, costly, and uncertain, and many new materials are being introduced into the marketplace and the environment each year without being tested at all.

The information available on hazard and toxicity comes from three sources: knowledge of the basic chemical properties of substances and their effect on biochemical pathways, animal

bio-assay studies in which large numbers of animals are exposed to high doses of a potentially hazardous substance, and human epidemiological studies in which large populations of people with different exposure levels to a substance are examined for statistically significant differences in disease levels.

The crucial issue in determining the likely effects of exposure to a chemical, however, is the long-term human response to low doses, and none of these sources of information is of much value for answering this question. Knowledge of biochemical mechanisms is not adequate to predict every harmful response while bio-assay experiments have to be conducted at high dose levels to yield significant results in a reasonable time, and human epidemiology studies have great difficulty finding populations that differ only in their level of exposure to the substance being tested and separating significant increases in disease rates from random fluctuations.

When estimates have been chosen, a RBA proceeds to add up all of the risks so derived and combine them with the known costs and benefits of the decision to measure the overall net social benefit. As is the case in a Cost-Benefit Analysis, this full treatment requires that all costs, risks, and benefits be expressed in terms of a common measure, usually Net Present Value in dollars.

While this description summarizes the full application of RBA, there are of course substantial variations in how it is conducted in practice. There is variation in whether all risks and costs/benefits are expressed on a common scale or simply presented in parallel, in the type of decisions analyzed, the range of options considered, the basis for comparing different options, and the stage of the decision process at which it is used. For a more thorough introductory treatment of RBA, see Crouch and Wilson (8) or Hertz and Thomas (9).

3) Criticism of Risk-Benefit Analysis.

Although RBA is an officially favoured technique for the assessment of public policy decisions in both Canada and the United States, it has been the object of much criticism. Lovins (10) and Hapgood (11) have written articulate criticisms from a political perspective. Shrader-Frechette (12) considers the philosophical basis for criticisms of RBA. Shrecker (13) provides a clear and balanced tre4atment of the arguments for and against RBA in a Canadian context.

The criticisms levelled against RBA can be grouped into four broad categories. First, as the exposition above suggests, extreme scientific uncertainty prevails on many of the most important questions related to current public debates over risk, such as the true probability of severe nuclear power plant accidents, the toxicity of prolonged low doses of pesticides and other chemicals, and the likelihood of sabotage or terrorism causing a catastrophic accident at an industrial facility. Not only are these quantities unknown, but it has been argued that they are in principle unknowable. In a classic article on the subject, Weinberg (14) called such questions "trans-science", for although they are questions that can be formulated in scientific terms, they can not be answered scientifically; the experiments that would be required to do so would take centuries to complete or can not be performed for ethical reasons. But to do a RBA, one must make estimates for such quantities as these. One must also make estimates of such quantities as the monetary value of a human life, which are not scientific questions at all. Critics of RBA such as Lovins argue that the need to make specific estimates of quantities that have such vast uncertainty or that can only be based on personal values renders any resultant calculation of total risk completely arbitrary.

The second major area of criticism -- as with cost-benefit analysis generally -- is that any approach based on the summing of total social risks, costs, and benefits necessarily neglects

distributive issues. Consequently, its ethical position is utilitarian, and it could favour decisions whose distribution of risks, costs, and benefits among social groups is morally and politically unacceptable. It could, for example, support a decision that imposed severe risks on one small group in order to confer monetarily larger benefits on another group. Or, to carry the point to its absurd extreme, if the monetary value of a human life is estimated at anything less than $25 million (which it almost always is), a mechanical application of RBA rules might seem to support a decision to sacrifice one Canadian selected at random in order to pay one dollar to every other Canadian.

The third major objection to RBA is that the requirement that costs, risks, and benefits be expressed on a common scale involves comparing quantities that are incommensurable, and putting prices on the priceless -- one's home, friends and family, the beauty of an unspoiled environment, and human life itself. In addition to the issues of arbitrariness outlined above, the critics argue that to make such calculations explicitly is a degradation of human values and can not be tolerated in a political decision-making process. Even though many individual and collective decisions can be retrospectively determined to imply a particular value of human life, collective discretion must not be exercised on the basis of some conscious awareness of such a valuation. Hapgood (15) makes this argument with reference to a city's decision to close its playgrounds after a child dies in a fall from a swing. He argues that a strong official could legitimately resist pressure to close the playgrounds by saying "We're not going to make every child in the city suffer because once in a blue moon a tragedy happens.", but that an official who responds that the benefits of the playgrounds exceed the costs as long as less than, say, one child per year dies appears so detached from human feelings and values as to be unworthy of a position of public trust. This argument has the feeling of a longing for past innocence about it.

It says in effect that decisions resulting in injury or death can be tolerated as long as the consequences are not known or not explicitly considered in making the decision.

The final class of arguments against the use of RBA is that the flexibility available in every stage of RBA -- in the range of choices considered and the basis for their comparison, in the estimates assigned to unknown scientific quantities and the values assigned to unmeasurables -- makes it an ideal vehicle for powerful groups in society who will use it to support decisions favourable to their own interests. Furthermore, it is argued that the large systematic biases that can be inserted in an analysis can also be effectively concealed from scrutiny, giving the rigged results an air of impartial authority. The critics differ on whether RBA is more likely to favour the interests of those groups who currently enjoy political power or those of a new technocratic elite, but they agree that it is anathema to any open, democratic political process.

4) What Other Approaches Are There?

The above criticisms have much validity. In fact, their validity is acknowledged by many supporters of RBA. But strong as they are, they do not constitute a definitive refutation of the use of RBA unless it can be demonstrated that some other approach to the making of public policy decisions on matters of risk is not equally full of problems. In fact, we argue that these criticisms are less statements of the irredeemably flawed nature of RBA than of its vulnerability to misuse and abuse. It is true that analysis can always be distorted so as to justify or rationalize a decision made on the basis of other criteria, in order to enable the official responsible to abdicate his or her responsibility on the pretext that “The numbers made me do it”; but analysis need not be so misused, and its correct use can have great benefits. We will argue that the

arguments against RBA are not lethal, and that other, more traditional approaches to public policy decisions are liable to be misused, and suffer from other more definitive weaknesses. Let us therefore consider four other possible approaches to decision making in the face of risk.

Decision-making by polls: "The People Have Spoken."

In contrast to the apparently autocratic character of the most extreme use of analytical decision making, the approach of letting polls determine policy -- or even of submitting the most contentious issues to referendum -- has significant attractions. It leans toward direct democracy and consequently has great populist charm, but also major problems.

The first class of problems is that this approach wastes the advantages of representative, as opposed to direct, democracy. Representatives are selected to devote more time and thought to the consideration of public policy issues than the average citizen can generally afford to do. A representative who refers every significant decision back to the constituents is clearly not fulfilling his or her responsibility.

The second class of problems is that the resulting decisions are likely to be simply inferior, morally, technologically, or economically. A majority of the populace, under duress, or under the influence of some charismatic individual, might momentarily endorse a decision that is clearly unacceptable to the basic values of the country, for example one that violated the rights of a minority group. Polls are so volatile and so subject to influence by advertising, the media, and conspicuous but anomalous events that a policy based on them would be liable to undergo major changes from week to week. And particularly on matters of risk, there exists abundant experimental evidence that people's uninformed choices are subject to major biases and

inconsistencies and that when confronted with the inconsistencies in their naïve choices, people tend to change their views to correspond more closely with those of a rational Bayesian decision-maker. For a thorough treatment of these biases and distortions, see Kahneman, Slovic, and Tversky (16). These reasons argue strongly against using public opinion as expressed through polls as the arbiter of public policy decisions.

Rights-based decision-making: "Justice Requires It."

Kluge (17), Lovins, Shrader-Frechette and others have argued that decisions involving risk should not be made on the basis of explicit calculation of values, but on the basis of a weighing of the rights of the conflicting parties. A similar argument is made for a judicial format for arbitration of scientific conflict in the Science Court proposals of Kantrowitz (18). The advantages of a judicial format are that a clear decision would be made in each case, for the judicial system has conventional ways of handling uncertainty in its rules of burden of proof and standard of proof. The openness of the process is also advantageous; when hearings are conducted openly, rules of evidence and procedure are publicly known, and reasons must be given for decisions, there is strong pressure for impartial decision-making and little opportunity to claim that decisions are covertly slanted to favour a particular group.

But the necessarily categorical nature of judicial decisions would seem to render them inappropriate for decisions involving the selection of a standard of safety from a continuum of possible values, and rigid rules of evidence and proof do not seem to allow enough subtlety to deal with the degree of uncertainty encountered in risk decisions. For if categorical decisions are to be made on matters of risk -- a given allegedly risky activity is either to be allowed to proceed,

or not -- and consistent standards are to be sought from one decision to the next, then either the decisions must be made on the basis of a prior, non-judicial decision determining an acceptable maximum level of risk, or the decisions must rule that in certain broad classes of cases no risk may be imposed. But when risk is a continuously variable quantity, "no risk" necessarily means "no detectable increase in risk", and consequently society's standard of safety is made to depend simply on the sensitivity of currently available measurement technology.

As our powers of observation increase, we are more and more compelled to face the inevitability of risky consequences in virtually all activity. As Lave (19) points out, pious hopes can appropriately be written into legislation as long as our measuring ability remains rather crude, but they become intolerable as our advancing sensitivity of measurement makes the true price of achieving them clearer. The only alternative is to face directly the decision as to what level of risk is socially tolerable in a particular situation, with all of the accompanying implications of loss of innocence. Lave asks that we consider the courage of the American FDA officials who first made public the amounts of rodent feces and insect parts that they were willing to tolerate in food. (Canadians will no doubt recall the discomfort encountered by Marc Lalonde as Minister of Health and Welfare, arising from his responsibility for the Health Protection Branch in its monitoring of the quality of hamburger for sale in Canadian stores.) Regarding uncertainty, judicial procedure cannot easily accommodate the fact that in many matters of risk, it can not be determined in advance who will benefit and who will suffer from a decision. Consider for example the current conflict over children's vaccination for Pertussis (Whooping cough). Most children benefit from this vaccination by being protected from a disease with a significant chance of mortality, but a small number of children (who cannot be detected in advance) suffer severe, sometimes permanently disabling, reactions to the vaccine

itself. There are now cases before the courts in Ontario in which parents of children who have suffered from the vaccine are seeking compensation and curtailment of the vaccination programme (20). But this post hoc dispute between those who suffered the ill effects of the vaccine and the government that imposed it does not adequately capture the decision to be made in advance, wherein each child is both a beneficiary and a potential victim, and so a dispute between conflicting interests in each child must be resolved. While issues such as the compensation due to the victims and the obligation to inform parents of potential risks may be within the competence of the courts, the issue of whether and how a vaccination programme should proceed is not so easily embraced. The imposition of a probabilistic harm simply cannot be evaluated in advance by the same standards as in retrospect when the victims are known.

Decision by Expert Judgement: "The Experts All Agree."

For their study of public inquiries in Canada, Salter and Slaco (21) chose as an epigraph the statement of a participant in one hearing that "Those who are experts have no questions". The practice of referring decisions to the consensual, intuitive judgement of a community of experts who will blend technical expertise, business acumen, and common sense, has much to commend it. It is a particularly popular approach when the decision to be made resembles those made within a traditional professional practice such as engineering or medicine. When an established body of professional knowledge exists, expert judgement can yield practical, successful decisions even on matters where scientific certainty is not strictly available. This is usually accomplished through robust rules of thumb that reflect abundant operating experience

and include hefty margins of safety, as for example in the design of physical structures such as bridges.

There are two major disadvantages to this process. First, most current contentious risk issues involve new technologies, new chemicals, or new environmental impacts, so there is not enough operating experience available for reliable informal professional standards to have developed. Consequently, when the experts exercise their judgement they are probably making guesstimates almost as arbitrary as those of anyone else. Second, the process of expert judgement is stubbornly non-transparent. In arriving at an estimate of total risk or a recommended decision, the expert must make a number of assumptions, and if professional knowledge does not grant a special authority to the expert's assumptions, then the political decision makers will want to know what the assumptions are, and what their impact on the total estimated risk might be. But if the assumptions are made implicitly and rolled together in the expert's head, then they are not available for scrutiny or for testing of effect. The same criticism regarding unjustified implicit assumptions has been levelled against Risk-Benefit Analysis but it is even more appropriate in the case of consensual expert judgement because the assumptions may never even have been consciously acknowledged by the expert.

Bootstrapping/Precedent. "This is the way we've always done it."

Any observer of organizational decision-making, private or public, will see that in the absence of compelling pressures to the contrary, decisions are made on the basis of precedent, habit, and standard operating procedures. In the realm of public decisions on risk, this approach can be seen in announcements that justify the imposition of a given risk by comparing it to other risks that are currently imposed and consequently presumed to be acceptable. You might, for example, hear that the risk from a certain source of radiation will be less than that which you

face every day from your luminous watch dial. Such comparisons, even if true, may be misleading; does anyone really know the consequences of exposure to luminous watch dials? While any canny administrator knows that major new approaches to policy are most difficult to push through the organization, ease of implementation is surely the only defense that one could muster for this approach. Such an approach probably won't upset anyone -- until something goes wrong. But the application of traditional standards, practises, and techniques to new decision problems is bound to lead to something going wrong sometime, simply because the environment has changed. This approach has neither rationality, consistency, equity, nor scrutability to commend it.

5) Conclusions.

These five approaches to decision-making -- analysis, public opinion and polling, legal procedure, expert judgement, and bootstrapping -- apply to more than just decisions on risk. They refer to just those forces and approaches that must be balanced in any public policy decision. But the high stakes and uncertainty associated with risk decisions render the balancing of these approaches more difficult, and the problems with each approach more evident and more acute.

Although the criticisms of Risk-Benefit Analysis are compelling, it surely does not look so bad when compared to the alternatives. It is vulnerable to profound uncertainty about probabilities and consequences, but so is every other approach. It explicitly requires pricing the priceless and placing monetary values on human life, but every other approach, even spontaneous intuitive decision-making, does so implicitly. It can be hijacked and used misleadingly to serve the interests of powerful constituencies, but so can expert judgement,

bootstrapping, and even the polls through the use of advertising and public relations. And if it does not explicitly address the issue of distribution of risks, it can at least be made to elucidate them.

Our conclusion then is a cautious endorsement of RBA as an approach to public policy decisions on risk; as in Churchill's view of democracy, Risk-Benefit Analysis is surely the worst system for decision-making on risk, except for all the others. The criticisms of RBA cited above, though, call to our attention some crucial issues in the use of RBA that must be addressed if it is not to be as fallible as its most vigorous detractors claim.

First is the appropriate breadth of its application. While the decision studied must be important enough to justify the expenditure of resources on a RBA, the breadth of its application must be limited. RBA cannot tell what ends society should pursue, because the analysis can only be conducted when the details of approach as well as the goal are specified. It can only be used to estimate the total social benefit of a specified way of seeking a specified goal, or to compare different ways of pursuing a specified, presumably politically chosen, goal.

The corollary of this restriction of application is that the significance of the results of RBA must not be over-stated. A favourable RBA does not necessarily mean that society should pursue the goal in question. If a RBA supports the construction of a particular kind of power plant in a particular location, this represents an endorsement only with respect to the alternatives that were considered; it does not indicate the need for such a plant, or indeed for any plant at all.

The possibility of RBA being used for obfuscation imposes a responsibility of clear communication on those performing the analysis. In order for a RBA to be a useful tool in policy debate, it must clearly indicate what problem was studied, what options were compared, and what assumptions were made for each option. All the assumptions made about unknown

scientific quantities, economic values, and value judgements must be clearly stated, and whenever possible, their impact on the results of the analysis indicated by repeating the analysis with different values, or determining at what values the analysis would tip over to favour other options. This process, called sensitivity analysis, is particularly important when the quantity in question is disputed or subject to wide uncertainty, and of major impact on the total estimated risk and benefit.

As well as communicating clearly the assumptions that went into the analysis, a responsible analyst should attempt to compare alternatives on as even a basis as possible, making equivalent assumptions about economic and population growth, price of inputs, and rate of technological innovation. It is also important that a sufficiently broad range of options be considered, if possible spanning the entire range of relevant political debate. Paying attention to these caveats can help prevent the suspicion that RBA is being used as its critics charge, to lend apparently authoritative support to decisions made on other grounds. Nothing can defuse these suggestions so effectively as the opportunity for critics to tinker with the analysis and try out their own assumptions. Raiffa (22) and Sebenius (23) report experiences of the impact that a revisable model can have on negotiations. In a number of situations, it has given negotiators incentive to move from an adversarial framework to a joint problem-solving framework and allowed opportunity and incentive for the abandonment of rigid bargaining positions.

Other issues that must be addressed in performing a RBA are the problem of partial vs. total quantification, and the inclusion of ethical values. Some writers on CBA and RBA, for example Mishan (24), argue that it is unnecessary and inappropriate to condense all results into a single measure, because profit gained and lives lost are truly incommensurable. He argues that an analyst should simply present best estimates of both the financial and non-financial outcomes

of each choice, and leave the political process to make the choices on that basis. Others, including Shrader-Frechette (25), point out that our political decision processes tend to favour those criteria that can be expressed numerically, and consequently that a format such as Mishan's would lead to the non-financial criteria being undervalued. She points out a number of examples of prominent uses of RBA and CBA in which this was the case. Consequently, she argues that in order for considerations of life and health, social equality, and environmental quality, to receive due consideration, they must be quantified, however arbitrarily, and the comparison of options presented on that basis. Political discussion would then be conducted both around the results of the analysis and around the reasonableness of the assumptions and valuations that went into the analysis.

When the distributive impacts of decisions are significant, they might be estimated by performing separate analyses for different affected groups. To what extent such dis-aggregation should proceed and how to present the results is also problematic. Some advocate putting explicit monetary values on distributional equity into the analysis, consequently representing all effects, distributive and otherwise, in a single figure; others argue for presenting separately the results of the analysis for each affected group. Some writers also advocate valuing explicitly other ethical considerations and rolling them up into the analysis. Such approaches obviously are speculative and controversial, and at present only supported by a few people.

So where do we come out? On balance, with due attention to these important qualifications and limitations, we would argue that RBA has a good chance of providing useful information, and not exhibiting the flaws that its critics allege that it suffers. Indeed, in a world of profound uncertainty and missing data, explicit and formal analysis still seems to offer the

most useful decision tool for the agonizingly difficult decisions that must be made on matters of public risk.

NOTES

1) The defining attributes of a decision involving risk are uncertain outcomes, and outcomes including possible harm to life and limb.

2) See, e.g., E. Siddal, "A Rational Approach to Public Safety", presented at Conference on Health Effects of Energy Production, Chalk River, Ont., September 12-14 1979; E. Siddall, "Control of Spending on Nuclear Safety", Nuclear Safety 21, 451 (1980); or Bernard L. Cohen, foreword to Inhaber, Energy Risk Assessment.

3) See, e.g., A. Lovins, "Cost-Risk-Benefit Assessments in Energy Policy", George Washington Law REview, 45, 5, August 1977, p. 912; or F. Hapgood, "Risk-Benefit Analysis", The Atlantic, 243, 1, January 1979, p. 35.

4) E.J. Mishan, Cost-Benefit Analysis (London: George Allen and Unwin, 1975).

5) A. K. Dasgupta and D.W. Pearce, Cost-Benefit Analysis (London: MacMillan, 1972).

6) Norman J. McCormick, Reliability and Risk Analysis (New York: Academic Press, 1981).

7) Norman C Rasmussen, "The Application of Probabilistic Risk Assessment Techniques", in Hollander, Simmons, Wood eds, Annual Review of Energy, 1976.

8) R. Wilson and E.A.C. Crouch, Risk-Benefit Analysis (Cambridge: Ballinger, 1982).

9) David B. Hertz and Howard Thomas, Risk Analysis and its Applications (New York: Wiley-INterscience, 1983).

10) Amory Lovins, op.cit

11) Fred Hapgood, op.cit

12) K.S. Shrader-Frechette, Science Policy, Ethics, and Economic Methodology (Dordrecht: D. Reidel, 1985).

13) T.F. Shrecker, Political Economy of Environmental Hazards, Law Reform commission of Canada, Protection of Life Series, 1984.

14) A.M. Weinberg, "Science and Trans-Science", Minerva, 10, 1972, p. 209-222.

15) Hapgood, op.cit, p. 36.

16) D. Kahneman, P. Slovic, A. Tversky, eds, Judgement Under Uncertainty: Heuristics and Biases (Cambridge: Cambridge University Press, 1982).

17) E-H W. Kluge, "What is a Human Life Worth?" address to Conference on Management in the Public Sector, Victoria BC, April 22, 1986.

18) A. Kantrowitz, "Controlling Technology Democratically", American Scientist 63 (5) 1975, p. 506.

19) L. Lave, "Regulating Risks", Risk Analysis 4 (2), 1984, p.. 79.

20) Toronto STar, May 4, 1986.

21) L. Salter and D. Slaco, Public Inquiries in Canada, Science Council of Canada, Background Study no. 47, September 1981.

22) H. Raiffa, The Art and Science of Negotiation (Cambridge Ma: Belknap, 1982), p. 337-339.

23) J.K. Sebenius, "The Computer as Mediator: Law of the Sea and Beyond", Journal of Policy Analysis and Management 1 (1), 1981, p. 77-95.

24) Mishan, op. cit p. 160-163.

25) Shrader-Frechette, op. cit p. 180-194.