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BEHAVIORAL ASPECTS OF COST-BENEFIT ANALYSIS

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NOTES

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(6) BEHAVIORAL ASPECTS OF COST-BENEFIT ANALYSIS.

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SUMMARY

Over recent years, the decision-making habits of military officers, government bureaucrats, business executives and labor leaders have gradually changed. Increasingly, when time permits, they are likely to order or conduct personally a formal analysis of their decision problem. Most analyses have what might be called a "cost-benefit" logic. For each possible action, one first enumerates all possible consequences, and then assesses how likely they are to happen and how good and bad they would be. Straight-forward computations produce the expected cost and expected benefit of the action. Usually, a preponderance of benefits over costs is a precondition for action. Any sound analysis will consider all possible actions (including inaction) in this light.

As the adoption of such procedures has grown, so has the scientific understanding of their validity. This paper reviews that literature with a focus on decision making in the public realm. Three generic sets of limits are described: (a) the unavailability of vital inputs (i.e., values for important costs and benefits), (b) the absence of procedures for assessing the validity of an analysis, and (c) the necessary incompleteness of any formal model of a decision situation. These limits have not always been fully appreciated in conducting analyses in the past.

Despite these deficiencies, however, cost-benefit analyses may have an important role to play in decision making, particularly when one considers the weaknesses of alternative approaches. Realization of this potential will require sensitivity to its strength and limits and to the complexity of the social and political situations in which it is applied.

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1. OVERVIEW

Cost-benefit analysis asks whether the expected benefits from a proposed activity outweigh its expected costs. Prominent variants are cost-effective analysis (comparing the relative benefits of alternative actions), risk-benefit analysis (in which the major costs are risks to life, limb or property), and decision analysis (in which the need to reduce all consequences to monetary units is avoided and the role of uncertainty is made more explicit).[1]

The expected cost of a project is determined by enumerating all aversive consequences that might arise from its implementation (e.g., increased occupational hazard), assessing the probability that each will occur, and estimating the cost or loss to society should each occur. Next, the expected loss from each possible consequence is calculated by multiplying the amount of the loss by the probability that it will be incurred. The expected loss of the entire project is computed by summing the expected losses associated with the various possible consequences. An analogous procedure produces an estimate of the expected benefits.

Although based on an appealing premise and supported by a sophisticated methodology, these procedures have a number of characteristic limits on their usefulness as management tools. These limits arise when the mathematical formalisms confront the fallible individuals who must conduct, accept, or implement them. Be they technical experts, lay interveners or

[1] Excellent expositions of these procedures may be found in a number of sources including R.L. Keeney & H. Raiffa, Decisions with Multiple Objectives (New York: Wiley, 1976); R. Layard (Ed.), Cost Benefit Analysis (Harmondsworth: Penguin, 1974); E. Stokey & R. Zeckhauser, A Primer for Policy Analysis (New York: Norton, 1978); H. Raiffa, Decision Analysis (Reading: Addison Wesley, 1968).

government regulators, these individuals all have, to some extent, limited capacity to process technical information, restricted resources to devote to the project at hand, irrational apprehensions about its consequences, intransigent prejudices about the facts of the matter, ulterior motives, and incoherent and unstable values on critical issues. Deliberately or inadvertently, these human properties tend to foil the best laid plans of cost-benefit analysts or the purveyors of almost any other scheme for managing technologies in society.

In considering the viability of any approach to management, it seems to be useful to have in mind a set of desiderata such as that in Table 1. Although this list is by no means definitive, it suggests the criteria a proposed approach must meet in order to merit wholehearted adoption. No proposal achieves perfect marks in each category. Analyzing the strengths and weaknesses of each proposal can show where it needs improvement and for which problems it might be most suitable.

Rather than consider cost-benefit analysis from each of these perspectives, some of which are covered by other addresses in this symposium, I will discuss the effects of three sets of limits on members of this family of analytical procedures. One set of limits is imposed by the unavailability of necessary inputs to the analysis. Without those inputs, the implementability of cost-benefit analysis must be seriously questioned. A second set of limits comes from the inability of the analysts to assess the validity of their work and incorporate that assessment into their guides to action. The absence of such appraisals creates problems for the logical soundness of such analyses and their ability to protect the public from unanticipated side effects. The third set of limits comes from the failure of these methods to address critical management issues. These include the acceptability of the political philosophy underlying the procedures and the feasibility of implementing their recommendations.

TABLE 1

CRITERIA FOR EVALUATING APPROACHES
TO MANAGING TECHNOLOGIES

Logically Sound

Implementable

Politically Acceptable

Respects Institutional Constraints

Open to Evaluation

Creates no Side Effects

Promotes Effective Long-Term Management

2. AVAILABILITY OF INPUTS

Performing a full-dress analysis assumes, among other things, that (1) all possible events and all significant consequences can be enumerated in advance; (2) meaningful probability, cost and benefit values can be produced and assigned to them; and (3) the often disparate costs and benefits can somehow be compared to one another.

Unfortunately, some of these tasks cannot be completed at all; while for others, the results are hardly to be trusted. Despite the enormous scientific progress of the last decade or two, we still do not know all of the possible physical, biological and social consequences of any large-scale energy project. Where we know what the consequences are, we often do not, or cannot, know their likelihoods. For example, although we know that a reactor core-melt-down is unlikely, we will not know quite how unlikely until we accumulate much more on-line experience. Even then, we will be able to utilize that knowledge only if we can assume that the system and its surrounding conditions remain the same (e.g., there will be no changes in the incidence of terrorism or the availability of trained personnel). For many situations, even when danger is known to be present, its extent cannot be known. Whenever low-level radiation or exposure to toxic substances is involved, consequences can be assessed only by somewhat tenuous extrapolation from the consequences of high-level exposure to humans or low-level exposure to animals.[2]

In all these cases, we must rely upon unaided human judgment to guide or supplant our formal methods. Research into the psychological processes involved in producing such judgments offers reasons for pessimism. A

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[2] Harriss, R., Hohenemser, C. & Kates, R. The Burden of Technological Hazards, Environment, 1978, 8.

rather robust result is that people have a great deal of difficulty both in comprehending information under conditions of complexity and uncertainty and in making valid inferences from such information. The fallibility of such judgment stems in part from the counter-intuitive nature of many probabilistic processes, in part from the lack of hands-on experience with low-probability and high-consequence events, and in part from the mental overload created by many problems.[3]

The failings of our intuitions are shown in persistent tendencies to neglect various kinds of normatively important information, such as population base rates (indicating how common a particular event is), sample size (indicating how reliable evidence is) and predictive validity. Other kinds of information are attended to, but given inappropriate interpretations. People tend to be more confident making predictions on the basis of redundant information than with independent information (although the latter has greater predictive validity). They readily find interpretable patterns in random sequences, and they assume that more information guarantees better performance even when it only generates confusion. When asked to synthesize information from their experience, people tend to misjudge the risks to which they are exposed. They remember themselves to have been more foresightful--and others to have been less foresightful--in past judgments than was actually the case, and they sometimes persevere in erroneous beliefs despite mounting, even overwhelming, contrary evidence.[4]

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[3] Slovic, P., Fischhoff, B. & Lichtenstein, S. Behavioral decision theory, Annual Review of Psychology, 1977, 28, 1-39.

[4] Tversky, A. & Kahneman, D. Judgment under uncertainty: Heuristics and biases. Science, 1974, 185, 1124-1131; Fischhoff, B. Hindsight ≠ Foresight: The effect of ourcome knowledge on judgment under uncertainty. Journal of Experimental Psychology: Human Perception and Performance. 1975, 1, 288-299; L. Ross "The intuitive psychologist and his shortcomings" in L. Berkowitz (Ed.), Advances in Social Psychology (New York: Academic Press, 1977.)

To the best of our understanding, these judgmental biases do not reflect folly, but the occasional (or frequent) inadequacies of people's best attempts to muddle through difficult problems. Often these attempts reflect the use of judgmental heuristics or rules of thumb that embody moderately valid appraisals of regularities in the world around us. In situations allowing a trial-and-error, successive correction approach to decision problems, these heuristics often work pretty well. However, where we (as planners or consumers) must get our decisions right the first time or suffer severe consequences, the limits of these heuristics may spell real problems.

These problematic tendencies are typically observed in situations where people's sole motivation would seem to be making the best, most "objective" judgment possible. Such situations are designed to avoid the additional problems engendered by the coloring of judgments by wishful thinking, self-serving motives, selective attention, cognitive dissonance and the like. Although the evidence is sketchy, there is at the moment no good empirical reason to believe that these problems are appreciably reduced when the judgment in question carries high (personal or societal) stakes or when the judge is a substantive expert forced to go beyond the available data and rely on intuition.[5]

Such results provide strong evidence for using formal methods for producing and combining information whenever possible--and for treating the results of such analyses with considerable caution because of their inevitable judgmental component.

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[5]Slovic, P., Fischhoff, B. & Lichtenstein, S. op cit.; Fischhoff, B. Cost benefit analysis and the art of motorcycle maintenance. Policy Sciences, 1977, 8, 177-202.

Once the consequences have been enumerated and their likelihood assessed, a price tag (in dollars or utiles) must be placed on them. When it comes to tradeoffs between deaths today and in the future, between sterility and black lung disease or between profits and lives, both the exigencies of our political processes and the indeterminate nature of cost-benefit logic force us to ask people for their opinions.

Such questions of value would seem to be the last redoubt of intuitive judgment. Unfortunately, however, subtle changes in how questions are posed can have a major impact on the opinions elicited. Worse yet, in situations where alternative questioning procedures elicit different preferences, the normative theory often offers no guide as to which of the different judgments is to be preferred. When people's judgments show this sort of lability, the method may become the message, leading to decisions not in the decision makers' best interest, to action when caution is desirable (or the opposite), or to the obfuscation of poorly articulated views.[6]

Many of these effects have been known since the antiquity of experimental psychology in the mid-1800's. Early psychologists concerned with the relationship between sensations and judgments about them found that both the threshold for discerning a sensation and the threshold for discriminating between two sensations depended on a variety of subtle aspects of how stimuli were presented and how responses were elicited. Different judgments were attached to the same stimuli as a function of whether those stimuli were presented in ascending (increasing on a physical continuum) or descending order, whether the set of stimuli was

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[6] Fischhoff, B., Slovic, P. & Lichtenstein, S. Knowing what you want: Measuring labile values. In T. Wallsten (Ed.), Cognitive Processes in Choice and Decision Behavior. (Hillsdale, N.J.: Erlbaum, in press.)

homogeneous or diverse, whether particular regions on the continuum were densely or sparsely represented, whether sequentially presented stimuli were relatively similar or disparate, whether values near the threshold of detection were included or not, and whether the respondent made one or many judgments. Even when the same presentation was used, different judgments might be obtained with a numerical or comparative (ordinal) response mode, with implicit instructions motivating speed versus accuracy, with a bounded or unbounded response set, with small or large numbers (subsequently normalized), or with verbal or numerical labels. The instability of judgment is heightened by the fact that perception is inherently accompanied by some random error and by idiosyncratic tendencies such as fatigue, locking in on stereotypic ways of viewing a problem, second-guessing the elicitor (what am I supposed to say?) and linking variables that should be independent (halo effects).

All of these problems emerge when people are questioned about their values or preferences. The elicitor must decide how many questions to ask and how to word them; what response format to use and how much time to allot for it. The preferences expressed will reflect in part the respondent's true beliefs, in part the method used to uncover them. Indeed, no decision is so clear cut in its options, events and attributes, no respondent is so mechanical, that these problems can be avoided entirely.

Particular kinds of lability seem to emerge when people are asked about value issues of the sort raised by proposed energy strategies. For such new and complex issues, with subtle interactions and gargantuan effects, people may have no articulated preferences. In some fundamental sense, their values are incoherent, not thought through. The desires they express at any particular time are those tapped by the particular question posed. That question may evoke a central concern or a peripheral one; it may help clarify the respondent's opinion or irreversibly shape it; it may even create an opinion where none existed before.

Listing a few specific effects may indicate the power an elicitor may deliberately, or inadvertently, wield in shaping expressed preferences. The desirability of possible outcomes is often evaluated in relation to some reference point. That point could be one's current (asset) position, or an expected level of wealth (what someone with my talents should be worth at time t), or that possessed by another person. Shifts in reference point are fairly easily effected and can lead to appreciable shifts in judged desirability, even to reversals in the order of preference. Consider, for example, how one might think about the same safety program conceptualized in terms of lives saved or lives lost, with the respective reference points of the current situation or an ideal one. As one gets closer to an event with mixed consequences, the aversiveness of its negative aspects may increase more rapidly than the attractiveness of its positive aspects, making it appear, on the whole, less desirable than it did from a distance. People may have opposite orders of preference for gambles when asked which they prefer (which focuses their attention on how likely they are to win) and when asked how much they would pay to play each (which highlights the amount to win). People may prefer to take a chance at losing a large sum of money rather than absorb a small sure loss, but change their mind when the sure loss is called an insurance premium. A relatively unimportant attribute may become the decisive factor in choosing between a set of options if they are presented in such a way that that attribute affords the easiest comparison between them.

Three important features of these shifting judgments are (a) people are typically unaware of the potency of such shifts in their perspective, (b) they often have no guidelines as to which perspective is the appropriate one, and (c) even when there are guidelines, people may not want to give up their own inconsistency, creating an impasse.

3. LIMITS TO SETTING LIMITS

The bottom line of a cost-benefit analysis is the analyst's best guess at the relative preponderance of costs or benefits. Before action can be taken, one must know how good that best guess is. Depending upon the breadth of the confidence intervals on the "best-guess" cost-benefit ratio, one might want to collect more data, install back-up systems to reduce some of the uncertainties, or abandon the project for one whose consequences are better known.

The analysts' standard practice for acknowledging and accommodating uncertainty in their inputs is through the judicious use of sensitivity analyses. The final calculations are repeated, each time using an alternate value of one troublesome probability or utility. If each reanalysis produces similar results, then the case is made that these particular errors do not matter. One way of viewing the research on judgmental biases described in the previous section is that it merely points to additional sources of error calling for sensitivity analysis.

Unfortunately, however, there are no firm guidelines as to which inputs might be in error or what is the appropriate range of possible values to be tested. The possibility of judgmental biases would, for example, be considered only if the analyst were aware of the relevant research and took it seriously. A further problem with sensitivity analysis is that it typically tells us little about how the uncertainty from different sources of error is compounded, or about what happens when different inputs are subject to a common bias. The untested assumption is that

errors in different inputs will cancel one another out, rather than compound in some pernicious way.[7]

The reasonableness of such an independence assumption seems weak when a set of judgments is elicited with the same procedure, inducing the same perspective. For example, asking about preferences in a mode that incorporated a reference to dollar values might persistently deflate the expressed importance of environmental or other less tangible values. To take an example from the elicitation of judgments of fact, the U.S. Reactor Safety Study called upon its experts to assess unknown failure rates by the "extreme fractiles" method, choosing one number so extreme that there was only a 5% chance of the true failure rate being higher and a second number so low that there was only a 5% chance of the true rate being lower. Research conducted with a variety of other tasks and subjects have shown that this technique routinely produces too narrow confidence intervals, so that the precision of these estimates is systematically exaggerated.[8]

Even if sensitivity analysis could handle the compounding of uncertainty, in some contexts it completely misses the point. Many of the effects discussed under the rubric of the lability of values refelct the introduction of new, possibly foreign, possibly distorted perspectives into a decision-making process. Invocation of sensitivity analysis will not

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[7] Fischoff, B. Decision analysis: Clinical art or clinical science? In L. Sjoberg & J. Wise (Eds.), Proceedings of the Sixth Research Conference on Subjective Probability, Utility and Decision-Making (Warsaw) 1977, in press).

[8] Lichtenstein, S., Fischoff, B. & Phillips, L.D. Calibration of probabilities: The state of the art. In H. Jungermann & G. deZeeuw (Eds.), Decision Making and Change in Human Affairs (Amsterdam: D. Reidel, 1977).

excuse the imposition of an elicitor's perspective on the respondent. Nor will it handle shifts in perspective that lead to reversals of preference.

In the end, determining the quality of an analysis is a matter of judgment. Someone must intuit which inputs are dubious and which alternate values should be incorporated in sensitivity analyses. Essentially, that someone must decide how good his or her own best judgment is. Unfortunately, an extensive body of research suggests that people are overconfident in the quality of their own judgment. Indeed, people have been found to be so overconfident in their degree of general knowledge that they will accept highly disadvantageous bets based on their confidence judgments. Furthermore, this bias seems to be impervious to instructions, familiarity with the task, question format and various forms of exhortation toward modesty.[9]

A particularly relevant version of this overconfidence emerges when people are asked to judge the completeness of the representation of a problem. Research here has shown a persistent tendency to underestimate what is left out and overestimate what is known. As before, while most of this psychological evidence is derived from work with laypeople, there is some systematic and considerable anecdotal evidence of similar processes at work with experts. Among the generic kinds of issues whose omission might not be adequately noted by energy analysts are: (1) the imaginative ways in which human error can mess up a system; (b) the range and rate of possible changes in people's values and behavior regarding energy consumption, (c) the number of unknown or undetected physical, biological,

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[9] Ibid; Fischoff, B., Slovic, P. & Lichtenstein, S. Knowing with certainty: The appropriateness of extreme confidence. Journal of Experimental Psychology: Human Perception and Performance, 1977, 3, 552-564.

or psychological effects of a new system; and (d) the interrelation between system components (e.g., common mode failures or the possibility of a system failing because a back-up component has been removed for routine maintenance).[10]

No analysis, performed in real time and with finite resources, claims to be complete or error free. Indeed, all responsible analysts include sensitivity analyses with their reports. The preceding discussion suggests, however, that it is hard to assess the adequacy of these analyses. We have an urgent need for a better understanding of what errors may enter into an analysis, how virulent they are, how they are propagated and compounded through the analysis, what can be done to reduce their impact, how we can assess their total impact, and what that assessment means in terms of action. In a sense, what we need is an error theory for cost-benefit analysis, supplemented by some empirical study of the fallibility of analyses conducted in the past.

The qualifications accompanying many (or most) analyses include reference to what could have been done with greater time and resources. These two commodities are, however, always going to be limited and we must know how well cost-benefit analysis serves us under realistic constraints. One conclusion of such an assessment might be that cost-benefit analysis is useless unless X% of the total budget can be invested in it; another might be that virtually all the value of a cost-benefit analysis comes from structuring the problem and conducting a few back-of-the-envelope calculations within that structure. A third possible conclusion is

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[10] Fischoff, B., Slovic, P. & Lichtenstein, S. Fault trees: Sensitivity of estimated failure probabilities to problem representation. Journal of Experimental Psychology: Human Perception and Performance, 1978, 4, 342-355.

that, in most situations, the judgmental components of cost-benefit analysis are so essential and so deeply buried that conducting a formal analysis merely creates an aura of solvability around problems that are quite dimly understood.

4. LIMITS OF SCOPE

Like all other procedures, cost-benefit analysis deals with only a segment of the management problem. The crucial question here is whether that segment can stand alone and is able to contribute to the rest of the process or whether its internal logic disintegrates when confronted with broader realities.

The segment addressed by cost-benefit analysis is that most amenable to formal analysis and least accessible to individuals without technical expertise. This is most certainly true in variants that rely heavily on tools like shadow pricing or revealed preferences to deduce what the people want without asking them. Some variants, like decision analysis, try to overcome this bias by incorporating elicitation procedures that can, in principle, be used with corporate executives, government regulators or people off the street. Despite such efforts, however, the very sophistication and centralization of the analysis gives added weight to the opinions of those who are articulate and close to the analyst.

When analytic resources are limited, the analyst must take cues from someone about how to restrict the alternatives and consequences considered. That someone is likely to be the one who commissioned the study. If commissioners all come from one sector of society and consistently prefer (or reject out of hand) particular kinds of solutions or consequences, a persistent bias may be produced. Such bias would determine what issues are never analyzed and how results are presented. If the commissioners are public officials, there may be a strong predisposition toward reports that bury uncertainties and delicate assumptions in sophisticated technical machinations or in masses of undigested data.

If one examines the public criticisms to which cost-benefit analyses are subjected, a number of themes emerge. One is that there is usually a population of experts who are angered because the sensitivity analysis did not include what they believe to be appropriate alternative values for some inputs. When these experts view themselves as having qualifications rivalling those of those experts who conducted the study, the obvious implication is that even the elite community involved is somewhat restricted, perhaps for reasons of political or academic power.

A second group of critics views the segmentation of participants as a more serious issue than the substantive topic at hand. Their main concern is that the use of analysis transfers power for societal decision making to a technical elite, in effect disenfranchising the lay citizenry.

One might argue that given the vagaries of lay judgment described above, such a transfer of power is in the best interests of even that lay public. Let someone competent do the job; we'll all be better off. The counter-argument has several facets. One is that every analysis requires a variety of judgments that might just as well be performed by lay people. Regarding questions of fact, when they are forced to go beyond their tools and data and rely on intuition, experts may be little better than non-experts. Regarding questions of value, being close to the action should not confer superiority on experts' beliefs. The second part of the argument is that there are higher goals than maximizing the efficiency of a particular project. These include developing an informed citizenry and preserving democratic institutions. The process may be more important than the product, making it important to devote the resources needed to make meaningful public participation possible.

Such participation requires new tools for communicating with the public, both for presenting technical issues to lay people and for eliciting

values from them. It may also require new social and legal forms, such as hiring representative citizens to participate in the analytic process, thereby acquiring the expertise needed to confer the informed consent of the governed on whatever decision is eventually reached. Such a format might be considered a science court with a lay jury. It would consider cost-benefit analysis as one input to its proceedings. It would also place the logic of jurisprudence above the logic of economic analysis, acknowledging that there is no formal way to summarize the issues at hand.

A third group of critics objects to the segmentation of the energy problem from the broader context of social issues. The critics often fight dirty or irrationally (from the perspective of the formal analyst) because they view the cost-benefit analysis as one arena in which political struggles are waged. Those struggles have a different logic than that of economic analysis. In them, it may be fair to engage in unconstructive criticism, viciously poking holes in analyses if the results do not support one's position. It may even be legitimate to ridicule or chastize analysts for ignoring issues (like income distribution) that were outside their analytic mandate.

Some representatives of this position would argue that the very reasonableness of formal analysis involves a political-ideological assumption, namely, that society is sufficiently cohesive and common-goaled that its problems can be resolved by reason and without struggle. Although such a "get on with business" orientation will be pleasing to many, it will not satisfy all. For those who do not believe that society is in a fine-tuning stage, a technique that fails to mobilize public consciousness and involvement has little to recommend it.

Thus, there are logics other than that of cost-benefit analysis, coming from legal, political, even revolutionary theory. Like the various ways of implementing the basic cost-benefit framework, each embodies both ideological predispositions and notions of how society operates. Considering these perspectives and the impact that problem formulation can have on people's judgments of their own values and the tendency for such analysis to create an aura of solvability, cost-benefit analysis no longer appears as a value-neutral procedure. This does not mean that it is not or cannot be made into the one technique most compatible with or capable of incorporating the broadest range of values in a particular society. It does mean that a political position of sorts is being taken when one adopts the procedure.

Like most choices involving ideologies, questions of taste are somewhat disciplined by questions of reality. Those who oppose cost-benefit analysis are responding in part at least to social concerns and facts to which the analysis is relatively or totally deaf. Attention to these concerns can strengthen an analysis and heighten its impact. For example, an analysis that ignores question of equity will often be overturned by those who come out on the short end of the project in question. Rather than let their work become a number game with no real effect, many analysts have attempted to exploit the kernel of truth in their critics' arguments and incorporate equity considerations. A more political perspective might also help one realize that formal analyses deal with ideal types often having no representation in reality. It is fairly easy to become enamored of abstractions and analyze projects that are never implemented in the way or at the time they are proposed.[11] Although the

[11] Majone, G. The feasibility of social policies. Policy Sciences, 1975, 6, 49-69.

method may be tricky, one could respond to this challenge by considering ensembles of possible representations of the proposed project (i.e., ways in which it might be carried out) or by requiring periodic updates of an analysis as the facts change. A broader perspective could motivate analysts to specify the assumptions about society upon which their analyses are predicated and heighten their sensitivity to the tenuousness of those assumptions. In the extreme, it might even lead them to reject analytical mandates that separate projects from their social context in ways that are not meaningful.

5. CONCLUSION

How well does cost-benefit analysis fare according to the various criteria listed in Table 1? What work is needed to make it fare better? Even though the preceding discussion has focused on some of these topics at the expense of others, a few words about each will give a flavor of what a fuller consideration might reveal.

5.1 Logically Sound

The cost-benefit family of analytic procedures has a logical foundation that is both carefully thought out and widely accepted in both political and academic circles. As a result, both its failings and its assets are better documented than those of its competitors. Although there are still important technical and conceptual problems to work out within the cost-benefit framework,[12] a useful investment of energy might be trying to clarify the relationship between that framework and the logic (or *ostensible logic) of other approaches. Are they really incompatible?* Can cost-benefit analysis be elaborated to incorporate the elements of truth embodied by the alternatives? Perhaps the weakest competition is provided by the "logic" uncovered in studies of people's intuitive decision making. Yet, even here, it is worth asking whether there is not a method in people's apparent madness. Are there not decision-making criteria overlooked by formal analysis yet essential for human welfare or psychological well being?

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[12] Pearce, D.W. "Social Cost Benefit Analysis and Nuclear Futures." In L. Sjoberg, T. Tyszka & J. Wise (Eds.), Decision analysis and decision processes. (Lund, Sweden: Doxa, in press)

5.2 Implementability

Like other computational enterprises, cost-benefit analysis rises or falls on the strength of its inputs. While enormous strides have been made to develop a cumulative data base on various topics, all too often the analyst is forced to rely on intuitive judgments. Judgments of fact tend to be subject to persistent biases that are only now beginning to be understood. Further work is needed here, particularly in studying the judgments of experts. Judgments of value tend to be highly labile and subject to complex and subtle manipulation by the questioning procedure used. Research is needed to produce techniques and settings that enable respondents to elucidate their own opinions.

5.3 Politically Acceptable

In contrast to the political objections to cost-benefit analysis raised earlier, one may cite a number of fundamental assets. The most important of these is the explicit expression of its structure and inputs, all of which are in principle open to question and revision. To realize this potential advantage, several developments are needed. One is procedures for communicating technical issues to laypeople (including regulators and legislators without a technical background) so that they can offer reasoned critiques. A second need is to develop some way for critics to perform their own sensitivity analyses, incorporating their own alternative values for various inputs. Such an opportunity might produce some surprising results, showing the conclusions of analyses to be much more (or less) robust than they initially appeared. It could also help allay fears that these conclusions represent the result of ingenious number-fudging by the analysts. In the back of many cynical critics' minds must lurk the thought that the experts have played around until they

found a constellation of values that looks benign but produces the recommendation most favorable to a particular point of view.

5.4 Respects Institutional Constraints

The initial popularity of cost-benefit analysis probably was due to its fitting well into the way in which business was done in various seats of government. Its continued success may be due to the ability of proponents to shape legal and governmental proceedings to accommodate this tool further. Its future prospects may depend on the successful resolution of several persistent problems. One is that it assumes a single decision maker; difficulties arise when there are many hands involved and many views to be incorporated. A second problem is that it is a one-time analysis; as a result, it is not as responsive to changing contingencies, preferences and scientific data as are the bureaucracies it is designed to serve. A third problem is that it requires a level of analytical expertise not possessed by many of the individuals involved in its use, producing aberrations and frustrations.

5.5 Open to Evaluation

As mentioned, cost-benefit analysis claims to be, if nothing else, open to inspection. To realize the promise of this claim, several developments are needed. Psychological research must find ways to help people appraise the limits of their own knowledge or, failing that, ways to assess how confident they should be given how confident they say they are. Theoretical efforts are needed so that analyses produce better assessments of their own limits and derive the action implications of that cumulative uncertainty. Since such efforts have their own inherent limits, empirical work is needed to review past analyses to explore their foibles and contribution (or lack of it) to the management process.

5.6 Creates No Side Effect

Disenfranchising the lay public is one possible side effect of the wide-scale adoption of cost-benefit analysis about which some segments of the public are quite agitated. Denigrating the importance of consequences that cannot readily be expressed in dollar or other quantitative terms (e.g., extinction, aesthetic degradation) is another. Making a fetish out of currently enjoyed benefits is a third.[13] In general, though, the implications of having a cost-benefit society are poorly understood.

5.7 Promotes Long-Term Effective Management

Cost-benefit analysis, particularly its sensitivity analysis component, has been instrumental in setting the research agendas of those concerned with understanding the effects of technological projects. To the extent that the priorities of such analyses are correct, this is a major contribution to creating a base of data relevant to sound management. It has also provided a framework within which talented economists could apply themselves to these problems. Finally, although it is criticized for emphasizing product over process, the cost-benefit analysis framework has probably raised the level of debate in many settings and broadened the understanding of even its harshest critics.

* * * * * * * * *

There is no verdict on cost-benefit analysis per se. One must consider it in the light of alternative approaches and in the context of

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[13] Mishan, E.J. What is wrong with Roskill? In R. Layard (Ed.), Cost-Benefit Analysis. (New York: Penguin, 1972)

particular situations that might accentuate its strengths or weaknesses. One must consider not only cost-benefit as it is today, but as it can be improved. One must consider not only the nice idea and the sparkling theory, but the integrity with which it will be applied.

Given the limits to human judgment and consensus described here, it is unlikely that cost-benefit analysis in a pure form will ever be practiced or followed anywhere. The critical question then becomes, does it degrade gracefully?

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Cost benefit analysis asks whether the expected benefits from a proposed activity outweigh its expected costs. Although based on an appealing premise and supported by a sophisticated methodology, these procedures have a number of characteristic limits on their usefulness as management tools. One set of limits is imposed by the unavailability of necessary inputs to the analysis. Neither the values nor the likelihood of many potential costs and benefits can be reasonably approximated by any formal computations. They must be

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derived in whole or in part by objective and reliable human judgment. Research has shown, however, that probability judgments are often quite unreliable and prone to systematic biases, while judgments of value are highly labile, changing with subtle (and formally irrelevant) shifts in the elicitation procedure. Relatively little is known about how to reduce these differences or assess the impact of those that remain. Related difficulties in assessing the quality of analyses comprise a second set of limits. There have been few systematic evaluations of formal analyses or attempts to develop a methodology for assessment. A third set of limits is the inability of the procedures to address critical issues in the management process they are designed to abet. These issues include the acceptability of the political philosophy underlying such procedures, the feasibility of implementing their recommendations, and the generation of managerial options. The contribution of cost-benefit analysis may be enhanced by reducing whichever of these problems are tractable, acknowledging those that are not, and clarifying the responsible role of cost-benefit analysis in the management process.