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APPLIED DECISION RESEARCH AND ENVIRONMENTAL POLICY

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A variety of concepts and tools developed in the area of decision research have been applied to help formulate policy solutions to environmental issues. In this paper the emphasis will be on three areas of environmental research. Firstly, we will focus on the construction of scenarios as a tool to improve the quality of decision making. Secondly, we will describe research in the area of environmental risk assessment and the public's perception of risks. Finally, cost-benefit analyses of environmental policy will be discussed. In each of these areas we will focus on the actual and possible role of (behavioral) decision theory and the relationship between applied decision research and policy decisions. Both the influence of decision research on the development of environmental policy and the influence of present and intended policies on the type of research being carried out are briefly discussed. It is concluded that political factors are as important as the quality of the scientific basis in determining the influence of research on policy making. It will be argued that insufficient emphasis on applied value has reduced the impact of research findings in the past. Finally, the extreme dependence on funding agencies often leads to a lack of continuity, hinders the development of this type of research and sometimes precludes the necessary basic research on the validity and reliability of assessment techniques.

A variety of techniques developed in the area of decision analysis have been applied to help formulate policy solutions to environmental issues such as long-term effects of pollution, the improvement of environmental quality and the relationship between experts and the public on issues such as technological risks.

Decision analytical tools such as multi-attribute utility analysis have been applied to a variety of environmental decisions; e.g. the siting of pumped storage facilities (Keeney 1979, 1980) and liquefied natural gas terminals (Kunreuther 1983), and toxic waste releases (Parkhurst 1984). In this paper the emphasis will be on more general policy issues. Three research areas are of particular importance in this context, i.e.; (a) the

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construction of scenarios as a tool to improve the quality of long-term policy strategies, (b) risk assessment and perception of risks, and, (c) cost-benefit analysis of environmental policy making.

In each of these three areas we will focus on the actual and possible role of psychological decision theory and the relationship between decision research and policy decisions. Both the influence of decision research on the development of environmental policy and the influence of present and intended policies on the type of research being carried out will be briefly discussed.

Scenarios as decision tools

An important step in the evaluation and development of policy measures is the construction of scenarios describing possible futures under various conditions. The development of scenarios has typically been applied to long-term effects of policy alternatives. Examples are scenarios for environmental policy (e.g., sulphur dioxide emissions and other acidifying substances, world energy supply strategy). Generally these scenarios describe the effects of alternative policy options for periods of 10 to 50 years. Moreover, given the complexity of the issues being studied, most scenarios are based on both empirically tested relationships between variables and more tentative 'educated guesses'. The long time-horizon accentuates the effects of this complexity. Scenarios always involve a variety of expectations and assumptions about variables such as population growth, changes in economic structure, technological developments, economic growth, changes in lifestyle, and the availability of non-renewable energy resources.

Initially, scenarios of environmental and economic development consisted of simple input-output matrices. Later developments more explicitly aimed to provide an integrated analysis of economic and environmental processes. The SEAS-model (Strategic Environmental Assessment System) is an early example of models attempting to predict possible long-term future developments. The model includes a wide range of environmental variables and also incorporates economic and energy-related variables, and their interactions (see e.g., Ratick and Lakshmanan 1980). The model was developed as a tool for the analysis, evaluation and development of long-term policy alternatives. The rather ambitious scope of the model led to the inclusion of considerable

numbers of variables, equations and data sets. Not surprisingly, this complexity, the relative inaccessibility and the substantial maintenance requirements (updating, adaptation to changing policy requirements etc.) led to a reduced applicability of the model. The present generation of models that deal with scenarios are less ambitious and usually focus on specific policy issues. Recent examples are scenarios for long-term energy policy (e.g., Sassin et al. 1983) and acidification in Europe (Alcamo et al. 1985). Even these less ambitious scenarios, however, are affected by the uncertainties and complexities of predicting futures.

Scenario studies usually provide an overview of possible policy measures and their consequences and thus provide a context in which alternative policy measures can be compared. The aim of most scenarios is simply to help structure the decision problem, i.e., selecting policy alternatives to reach specific goals. The complexity of many of the policy issues implies that many scenario studies are simplified models of possible future developments and can best be described as helping to focus the attention on crucial variables and steps in the decision process. Although there have been some attempts to develop description of various types of scenario studies (e.g., Ducot and Lubben 1980) this field of study lacks standard methodologies (see also Biel and Montgomery 1986). Generally most studies do not present a detailed account of the techniques being applied. Procedures that have been suggested for constructing scenarios are frequently developed for other purposes; e.g. morphological analysis and the Delphi method. Moreover, the variety of techniques being used is quite substantial and most of these are not accompanied by theoretical justification and/or empirical validation.

The lack of generally accepted methodologies and the need to reduce complicated issues to manageable proportions imply that the study and development of scenarios leaves considerable space for intuition. Not surprisingly, some researchers in the field of psychological decision theory stressed the need for more explicit incorporation of cognitive factors that can influence scenario construction (e.g., Jungermann 1985; Vlek and Otten 1987). Most research on scenarios, however, is dominated by economists, engineers, and planners. Contributions from the social sciences, and particularly from psychology, are relatively rare. As described in the previous paragraph, psychologists usually refer to the study of heuristics and biases as a possible source to improve the quality of scenario construction.

The study of heuristics and biases tends to be dominated by attempts to expose systematic errors and inferential biases in human reasoning. Below, we will briefly mention a number of factors that constitute potential difficulties in scenario construction. The argument that these should be taken into account if decisions are to be improved in applied areas such as scenario construction will be briefly discussed.

Probability assessment

Information about the probability of the various outcomes of a scenario may be available prior to the construction, be gathered during the construction process or be inferred from similar cases. In all these cases it is important to know how people use information about the probability of outcomes (e.g., relative frequency of the outcomes in the past) or how people estimate the probabilities of specific outcomes.

There are various factors that can affect the accuracy of people's estimation of probability. These factors are all related to the incorrect use of statistical evidence. Prior probabilities, the effect of sample size and conjunctive probabilities seem not clearly understood and are used incorrectly or underutilized in probability estimates. Generally, intuitive judgments of probability seem strongly influenced by relatively concrete, and vivid instances. Further factors that can affect probability estimates are the over-weighting of instances that conform to prior expectations. All in all, it seems clear that people find it difficult to make probability estimates. This is illustrated by the ease with which concrete instances can affect probability estimates and the substantial effects due to the introduction of anchor values (e.g., Kahneman Slovic and Tversky 1982).

It needs to be stressed, however, that most studies on heuristics involve discrete judgment tasks at a single point in time, while in more natural context judgments, decisions and outcomes evolve and influence each other continuously over time. One would expect therefore that the kind of information with which we are best adapted to deal is continuous, redundant and patterned over time. Judgments, then, are typically made on a data base that is redundant rather than randomly generated, and that can constantly be updated. Moreover, because of the possibility of correction through feedback, judgments do not generally have to be made once-and-for-all. Many studies fail to simulate the natural context of judgments and decisions, and it has been suggested

that for this reason 'errors' and 'biases' can be experimentally demonstrated with such relative ease (e.g., Phillips 1983). These errors and biases are real enough, and testify to people's tendencies to resolve problems on the basis of rules of thumb rather than recourse to first principles. Such evidence, however, falls short of demonstrating that these rules of thumb, strategies or heuristics are irrational, unreasonable or invalid with respect to the context in which they are more typically used.

In sum, not enough is presently known about the generalizability of the findings obtained in this research area. Questions such as whether the stimuli and designs used in experimental demonstrations are typical or exceptional need further attention. Another issue that needs to be resolved is whether people can be trained to avoid the various errors and biases in their use of statistical information and their estimates of probability (see e.g., Jepson, Krantz and Nisbett 1983).

Assessing and applying values

There are a number of ways in which values might be inadequately considered in decision making. Three will be briefly discussed in this section:

- (a) relevant values may be overlooked,
- (b) uncertainty about the relevance of various values, and
- (c) difficulties in assessing values.

The quality of decisions can be seriously affected if one ignores important positive or negative features of one or more of the choice options. Some researchers (e.g., Janis and Mann 1977) argue that the quality of decision making should primarily be judged by the extent to which the processes are complete and unbiased. A potential bias is related to the tendency to look for confirming evidence, i.e., negative features of favoured options tend to be overlooked. Apart from the failure to include value considerations, it occasionally happens that people are not sure what values are relevant. Fischhoff, Slovic and Lichtenstein (1980) point out that this is especially the case with unfamiliar and complex issues such as those related to scenario construction. Due to lack of experience and the complexity of the many possible consequences people might not even know how to begin

thinking about certain issues. Many of today's issues such as nuclear energy and the use of chemicals with possible long-term consequences for the environment and public health seem to fall in this category.

Even if one knows which values are of relevance to a specific decision it might be difficult to assess these values. In some decision situations one will have to estimate value outcomes indirectly. Sometimes, however, one may rely upon feature(s) they have little diagnostic significance. Procedures to elicit underlying value structures in order to make these more explicit seems especially important in the context of scenario construction. Quite often, disagreement about the validity of scenarios is related to differences in values, partly because values determine to a large extent the focus of scenario studies.

Scope of scenarios

Another frequently made suggestion by social scientists is the necessity to include social and psychological impacts in scenario studies. Attempts to include these aspects are made in the areas of 'Environmental Impact Assessment' and 'Technology Assessment' (e.g., Covello et al. 1985). Inclusion of these aspects in scenario studies would considerably increase the complexity and uncertainty of scenarios. For this reason it seems advisable to limit oneself to relatively obvious and major social impacts. The fact that most scenarios attempt to deal with long-term futures restricts the number of social and psychological impacts that can be included in such scenarios. One could, for instance, take into account aspects such as amount of leisure time and the distribution of the population. More complicated social and political implications are extremely difficult to incorporate in scenarios. Generally, one seems to acknowledge the need to incorporate specific social aspects (see e.g., Jungermann 1985), but nothing much is done about it. The latter seems mainly due to methodological problems (e.g., defining and measuring the concepts) and the difficulties in predicting social and political changes and their impacts.

Political context

Scenario studies can play an important role in environmental policy processes. This influence is most noticeable when the following conditions are met:

- (a) the consequences described in the scenario are relatively severe,
- (b) relative consensus among the scientific community that the effects or consequences are likely to occur (i.e., several scenario studies lead to similar conclusions),
- (c) concrete, empirical evidence in support of the consequences described in the scenario,
- (b) public awareness of the issue and public support for policy measures,
- (e) the discrepancy between proposed policy measures and existing policy is not too large.

The importance of (c) and (d) should not be underestimated; these factors have a substantial influence on political agenda setting. For instance, the relatively low priority given to issues such as the CO₂ effect and its consequences for the world climate, the reduction of the O₃ layer, and environmental problems in some developing countries could well be related to these factors. The acid rain issue, on the other hand, receives most attention in those countries confronted with the first concrete evidence of the consequences of acid rain. The above examples concern environmental issues that are clearly not restricted to specific countries. As a consequence policy measures need to be taken at a supranational level. This further complicates the political context due to the different interests of the countries involved. In Europe, for instance, Great-Britain did not follow the decision to reduce the SO₂ emission by 30% over the next five years. Great-Britain (especially England) is only marginally affected by the consequences of acid rain due to the prevailing winds, and decided that more scientific evidence is needed to establish the relationship between acid rain and the dying of forests.

Although scenario studies can help in the process of developing adequate policy measures their impact is less pronounced when the discrepancy with existing or intended policies is substantial. To give just one recent example: a recently developed series of scenarios describing the long-term consequences of the production of solid waste (Vos and Jansen 1987) received less attention, was not published by the government agency that funded the research and the funding agency further recommend not to accompany the (internal) publication with a press release. On the other hand, when scenario outcomes are in accordance with intended policies they function primarily as 'scientific'

support for these policies and receive considerable attention. In these circumstances policy-makers tend to interpret the possible scenarios as objective, extremely reliable forecasts, and references to confidence intervals of the predicted outcomes are not always appreciated. These examples are exceptions but they do suggest that policy makers sometimes prefer to obtain scientific information to help develop policy *and* also have complete control over this information. The latter is most likely when scenarios are used to defend existing or intended policy measures.

Risk assessment and risk perceptions

The risks associated with a number of recently introduced technologies led to the need to develop quantitative risk assessment techniques in order to base policy on 'objective' facts. This expectation has since been shown to be rather optimistic. Risk assessments generally leave many degrees of freedom to the analyst and the results of an assessment are clearly influenced by implicit assumptions and include many intuitive judgments. The large uncertainties involved necessarily push the evidence out of the realm of 'facts' and into the realm of 'opinion'. One of the reasons for this uncertainty concerns the limited knowledge of dose-response relations that should underly risk assessments. A lot of research has been directed at risks associated with nuclear power generation but even in this area knowledge about a number of aspects is relatively limited (e.g., long-term effects of routine low-level emissions). In other areas knowledge about dose-response relations is extremely limited. For instance, there are about 80,000 commercially produced compounds with possible negative consequences for the environment and/or public health. Only a fraction of these have been subjected to quantitative risk assessments. The most important problem in this research area is that the chronic health effects of chemicals cannot be verified by direct experimentation.

Not surprisingly, relatively little research has been done on methodological and procedural aspects of risk assessments and their relation to policy decisions. Lathrop and Linnerooth (1983) studied the siting of an LNG facility on the California coast and concluded that the political decision process bears little resemblance to the analyst's perspective. They suggest procedural changes (e.g., rules of evidence, or

standards to which risk assessments must adhere) in order to improve the use and effectiveness of risk assessments in the development of public policy.

Environmental policy is likely to depend more and more on quantitative risk assessments, especially in the area of nuclear energy and hazardous industrial activities. Environmental policy is based on both risk management and the active development of risk analysis tools. There seems to be a general tendency to make the practice of risk assessment more consistent throughout the various policy areas (see e.g., Russell and Gruber 1987). For instance, the Department of the Environment in the Netherlands has commissioned the development of a computerized risk analysis package, and also prepared a general policy of having one standard for all installations: a risk level of 10^{-6} is acceptable. The actual policy is slightly more differentiated (distinguishing between a lower limit, upper limit, and a grey zone in between), but the thrust is still to have one overall standard. The software is now available (the so-called SAFETI package; Technica 1984), but concrete applications have not yet been made public. The debate surrounding this initiative was both political and scientific. Industry argued strongly against the introduction of one standard, insisting that allowance should be made for specific circumstances of a particular installation and locale. One of their points, however, concerned the crudeness of the computerized risk analysis and the unreliability of many of the data to be fed into it. Given the uncertainties associated with most risk assessments it is rather surprising to see that policy tends to move into the direction of a general norm (10^{-6}). Rip (1986) suggests a different solution and argues that pragmatic rationalism in combination with expert accountability (presently too often neglected) could improve the quality of policy decisions. A further benefit could be improved relationships with the public and hence increased public acceptance of policy decisions concerning hazardous industrial activities.

Research on risk assessment is generally dominated by technical experts. Psychologists focussed their attention on the gap between these experts and the public and the substantial public opposition to some technological developments. Most of this research focussed on nuclear energy because of the dramatic opposition it has engendered in the face of experts' assurances of its safety.

Risk perception

Although the experts' assessments of the risks of nuclear energy indicate that these are not greater than, and perhaps substantially less than, those of other generally accepted technologies, the public distrust of nuclear energy is considerable. Several studies attempted to establish whether the public's intuitive assessments are related to the expected losses criterion used in technical risk assessments. Apart from an overestimation of risks with low expected losses and an underestimation of risks with high expected losses the intuitive assessments of lay people seemed not that far out. This led to the necessity to focus on other possible explanations for the limited public acceptance of the risks associated with nuclear energy.

A number of studies have revealed that the lay public defines risks in much broader terms than the expert. One of the conclusions of this line of research was that nuclear energy elicits extraordinary levels of concern, particularly because of the characteristics of the hazards that it poses (e.g., Fischhoff et al. 1978; Vlek and Stallen 1981; Slovic 1987). Most prominent among these are the potentially catastrophic and involuntary nature of possible accidents, and the fact that the hazard poses an unknown threat which is difficult to combat. The public's concept of risk, therefore, seems to be heavily influenced by the catastrophic nature of conceivable consequences and a number of qualitative risk characteristics such as voluntariness, possibilities of personal control and the fact that the hazard is relatively unknown. The concept of risk, however, does not embrace all the relevant terms of acceptance. The public's perceptions of risks are built on values, attitudes and sets of attributes which need not be similar to the representations of the experts and those involved with energy policy.

Beliefs and values

Public acceptance of nuclear energy is not only a matter of perceptions of risks and benefits but is clearly related to more generic issues. Eiser and Van der Pligt (1979) addressed this point and asked participants attending a one-day workshop on nuclear energy to select the five factors which they felt 'would contribute most to an improvement in the overall "quality of life"' from a list of nine. Nuclear proponents generally stressed the importance of 'advances in science and tech-

nology', 'industrial modernisation', and 'security of employment'. Nuclear opponents put most emphasis on 'conservation of the natural environment' and stressed the importance of 'decreased emphasis on materialistic values', and 'reduction in scale of industrial, commercial and governmental units'. Similar findings were obtained in the Netherlands (Van der Pligt, Van der Linden and Ester 1982). These findings serve as a reminder of the fact that the issue of nuclear energy is firmly embedded in a much wider moral and political domain (see also Douglas and Wildavsky 1982).

Communicating risks

As a consequence of the public's continued concern about risky technologies recent research efforts focus on attempts to inform and educate people about risk. An important conclusion of risk perception research concerns the presentation of quantitative risk estimates of various hazards. Presentation of these estimates expressed in some unidimensional index such as annual probability of death or reduction in life expectancy are not likely to help bridge the gap between experts and the public. People's attitudes and perceptions are determined not only by this sort of unidimensional statistics but also by various qualitative characteristics described earlier in this section. Moreover, risk debates are not merely about risk but are often related to other social or ideological concerns. In this context statements such as 'the annual risk from living near a nuclear power plant is equivalent to crossing your local highstreet twice a week' give inadequate consideration to important differences in the nature of the two risks. It seems necessary, therefore, to use a broader conception of risk when attempting to characterize, compare, communicate *and* regulate risks. Fischhoff, Watson and Hope (1984) have attempted to develop a more comprehensive measure of risk and showed that variations in the scope of one's definition of risk have a considerable influence on the assessment of risk from various technologies. Generally, knowledge about many issues relevant to risk communication is rather limited. Covello, von Winterfeldt and Slovic (1986) conclude that, notwithstanding the complexity of many risk issues, interactive and participatory approaches to risk communication appear to offer the greatest promise of better, less controversial, or less diversive decisions.

Political context

Psychometric risk research has seen a spectacular growth in the late 1970s followed by an equally dramatic decline. This decline can partly be explained by political factors (changing priorities) but seems also related to 'shortcomings' of the research and unrealistic expectations of the funding agencies. The early findings of psychometric research pointed at the importance of a number of qualitative characteristics. These novel findings led to an increase of research activities. Funding agencies had high expectations of psychological research as a possible means to help understand public opposition to nuclear energy and end the political stalemate. Lack of experience with this type of research resulted in relatively vague, inarticulated descriptions of the issues to be studied. Similarly, most researchers were relatively inexperienced with this type of applied, policy-oriented research. As a consequence, various efforts focussed on theoretical and methodological aspects of models of human perception and decision making. With the benefit of hindsight it does not seem surprising that the funding agencies found it difficult to translate the bulk of these findings into concrete policy measures.

This discrepancy between the high expectations of funding agencies and the modest applicability of the research findings is not the only reason for the reduced support for this type of research. Most of the research referred to both rational and biased elements in public reactions to technological hazards. Occasionally this led to interpretations of the findings as further proof of the 'irrationality' of public. This is exactly the kind of argument used by proponents of the viewpoint that public participation in decision making only leads to unnecessary delays in technological development and economic growth.

Present research in the area of technological and environmental risks focusses to a large extent on risk management. Most of this research is technical and deals with issues such as handling uncertainty in policy decision making, and further development of risk management models. As compared to research carried out in the last decade, present research is less explorative and focusses on more specific issues, such as the regulation and communication of risks. One of the most important messages of this research is that lay people's basic conceptualization is wider than that of the experts and reflects legitimate concerns that are generally omitted from expert risk assessments. As a consequence, risk

communication and risk management efforts frequently fail. It seems necessary, therefore, that each side respects the views of the other in order to develop policy strategies that are more structured as a two-way process. The recent accident at Chernobyl has helped funding agencies to realize that much of the controversy generated by risk assessment policies derives from the association between such policies and profound issues that arise from potentially conflicting desires for prosperity, equity, safety, and environmental quality.

Cost–benefit analysis

One of the decision procedures frequently employed to improve the quality of decision making is cost–benefit analysis. The technique of cost–benefit analysis can be broken down into six steps:

- (1) enumerate all the adverse consequences of a particular course of action;
- (2) estimate the probability that each consequence will occur;
- (3) estimate the cost (loss) should each occur;
- (4) calculate the expected loss from each consequence by multiplying the amount of loss by its probability of occurring;
- (5) compute the expected loss for the course of action by summing the losses associated with the various consequences;
- (6) repeat the procedure for benefits.

Many different techniques go by the name cost–benefit analysis. The label has been used for almost any explicit consideration of the monetary advantages and disadvantages of one or more options. Generally, these values of the good and bad consequences of each option are assessed with the tools of economic theory (e.g., market behaviour). Cost–benefit analyses, however, involve several rather strong assumptions. It is assumed, for example, that all important consequences of an action can be enumerated in advance, that the probability of their occurrence can be reliably estimated and that different kinds of costs (for instance in the context of rescue operations: financial versus pain, suffering and loss of life) can be compared. All of these assumptions can and have been questioned. But surely the most controversial aspect of cost–benefit analysis is the need to compare disparate costs. Gener-

ally, cost-benefit analysis aims to include all consequences amenable to economic valuation and to exclude all others (see e.g., Parish 1976). Many practitioners tend to evaluate only those commodities and services that have readily measurable market values (e.g., construction costs, wages). Indirect economic evaluation with the help of demand principles, shadow prices, and the like are sometimes used to extend the range of consequences to which a monetary value may be attached. Although there is some disagreement as to how far these methods of cost-benefit analysis should be extended to also include social and political consequences (see e.g., Mishan 1976; Parish 1976), policy makers have exerted considerable pressure to include these 'soft' values.

Application to environmental issues

One of the consequences of this development is that behavioural scientists have become more involved in environmental cost-benefit analysis. This increased involvement was partly due to the need to develop benefit measures and non-market pricing techniques for valuing environmental attributes. For instance, initially, economic assessments of the impact of noise tended to focus on aspects such as property values; i.e., the relationship between traffic noise and residential property values as a possible basis to cost-benefit analyses of noise abatement projects. Next, epidemiological studies attempted to extend the scope of cost-benefit analysis by quantifying the consequences of noise on public health. This attempt had mixed success due to the complexity of the issue and the many confounding possible antecedents. Finally, psychologists entered this field with the aim to develop non-market valuation techniques to assess environmental quality. Difficulties in the quantification of benefits such as stress-related psychological and physical reactions to reduced environmental quality led to a search for techniques that could provide quantitative, monetary estimates of environmental quality. Currently economic and psychological research in this area tends to emphasize the measurement of benefits of environmental policy. This emphasis is the result of the need of policy makers to base their policy measures on extensive cost-benefit analysis.

This need was felt most clearly in areas such as environmental policy. Spending in this policy area was under threat as a consequence

of the cuts introduced in the early 1980s. Environmental quality is a public good that is not exchanged on the market and, therefore, does not have market prices that can be used to determine the value of that resource in a cost-benefit analysis. As a result, techniques have been developed to estimate the value to society of these unpriced resources. One technique has been to use information from expenditures on related goods or activities, such as travel costs to a recreational site. A more direct method of analysis, however, simply requires individuals to reveal their personal valuations of these goods in hypothetical markets. Termed contingent valuation methods, these approaches ask individuals in a survey or an experiment to reveal their personal valuations of increments (or decrements) in unpriced goods. These approaches construct a contingent or hypothetical market by defining the good or amenity of interest, the status quo level of provision and the offered increment or decrement, the institutional structure under which the good is to be provided, and the method of payment.

With the help of this method it is attempted to incorporate non-market values such as 'option', 'existence' and 'bequest' values in cost-benefit analyses. The method usually relies upon contingent bidding techniques and has been applied to a wide variety of environmental commodities ranging from water quality to the condition of forest stocks (e.g., Crocker 1985; Croke, Fabian and Brenniman 1986).

Contingent valuation methods are not sufficiently developed to allow widespread application. With few exceptions, studies in this field have avoided theoretical examination of the sources of bias and how they might be observed or not observed in experiments involving bids. The problem of strategic bias, for instance, has not been followed up by research. A number of potential biases in the design of the process of revealing preferences have been examined, although methods to remove those biases have hardly been developed. Major biases include the effect of the starting point of the bidding procedure, the vehicle of payment and whether the individual took the experiment seriously. Researchers frequently refer to the need for further research with an emphasis on laboratory experiments (e.g., d'Arge 1985). This imbalance has not resulted in a more cautious use of contingent valuation methods. Research focusses on issues such as the quality of forests, and benefits of noise-reduction measures. Psychologists are usually called upon to deal with methodological aspects of the survey techniques employed. Generally, the funding agencies are not prepared to support

the necessary basic research and seem primarily interested in the obtained monetary estimates of the benefits of environmental policy.

Political context

Contingent valuation methods are an increasingly important tool for policy makers to defend the expenses of their existing and intended policy measures. Validity and reliability of the method are seen as relevant, but of secondary importance as compared to the urgent need to defend the costs of policy measures in a time when governmental budget allocation is highly competitive. It is interesting to note that these monetary estimates of non-market values are usually made for the effect of existing or intended policy measures, i.e. they hardly play a role in the comparison of various alternatives. In other words the emphasis is on providing monetary estimates of the benefits of specific policy measures (e.g., preserving a marsh or a forest). In a sense, this approach is at odds with the idea of interval-scale utility. Welfare economists want to measure values in money, using observed willingness to pay as a basis for their measurements. Decision analysts would prefer to measure the values discussed in this section as utilities.

In summary, decision theory seems to play a marginal role in recent developments of cost-benefit analyses. Psychologists are involved in attempts to extend the scope of cost-benefit analyses of environmental policy measures, but the application of these assessment techniques is primarily determined by their usefulness to policy makers (i.e., resulting in monetary estimates of benefits). As a consequence, techniques that have not been extensively tested are applied to a wide variety of policy issues.

Conclusions

The last decade has seen a growing number of applications of notions developed in the area of decision theory to help formulate policy decisions. In this paper we focussed on environmental policy and briefly reviewed three fields of research: scenario construction, risk assessment and risk perception, and cost-benefit analysis. The application of decision-analytic concepts and tools is a difficult and complex task. Generally, political factors seem as important as the quality of the

scientific basis of the research in determining the impact of research findings on policy development. A number of techniques have helped to formulate policy measures (e.g., scenario construction, risk assessment). Both the uncertainties of these techniques and the lack of emphasis on applied value have sometimes reduced the impact of research findings on environmental policy. One of the major problems of applied decision research in this area seems to be the lack of continuity. Changing political priorities can have massive impacts on the type of research being carried out. For instance, political factors played an important role in the decline of applied psychometric risk perception research. Continued public opposition to specific technologies led to renewed interest in this type of research focussing on risk management and communication. The sudden rise of contingent valuation methods is another example of the effects of political factors. The urgent need to defend costs of policy measures due to increasingly tight governmental budget allocation to the various policy areas, resulted in a rapid growth of research aiming to defend existing or already determined future policies, instead of helping to compare and select policy options.

Increasing the impact of research findings by putting more emphasis on the applied value of research, decreasing the dependency on funding agencies and, hence, closer links between basic and applied decision research, seem necessary to make a lasting contribution to both basic and applied issues in the context of environmental decision making.

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