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Many of the most serious potential environmental problems are those for which the effects of certain processes are highly uncertain with respect to both their spread and duration. As the uncertainty increases, so does the difficulty of evaluating the associated environmental damage or the marginal social costs. Moreover, the wider the spread and the longer the duration of these problems, the narrower is the scope for a market solution involving the allocation of property rights. Intractable problems of this sort have led to strong support for the "precautionary principle," which involves the commitment of resources today in such a way as to safeguard against distant and potentially catastrophic outcomes in the future. This paper's main concern is the identification of the conditions in which the precautionary principle is appropriate, and the way in which the principle modifies the decision-making process. It is argued that it leads to a sequential approach in which the decision maker reserves judgment about the uncertain outcomes of each activity, assuming the worst case outcome until evidence is provided to the contrary.

Discounting, Valuation, and Treatment of Future Generations

The strongest argument in favor of the precautionary principle is the fact that environmental effects which are both distant in time have a low probability of occurring receive very little weight in the decision-making process. There are two main reasons for this: 1) the rate of discount; and 2) the valuation of resources under the current structure of property rights. Both raise ethical questions with respect to the right of present generations to put at risk not only the marginal economic benefits but the very survival of future generations.

The social discount rate is a measure of the rate at which it is considered socially desirable to substitute consumption in the present for consumption in the future. This is an issue because it involves ethical judgments concerning intergenerational equity. If discount rates are positive, a development strategy that is unsustainable may seem optimal today. If the discount rate is set at zero, on the other hand, then a development strategy will only be considered optimal if it yields a constant stream of income in all periods. The discount rate implies a judgment about the responsibility of the present to the future for distant but catastrophic impacts. Positive discount rates screen out even major future costs from present decision making.

Historically, mainstream economics has been strongly critical of the ethical judgments inherent in positive discount rates. More recently, however, the sovereignty of the current generation of consumers has been invoked to support the propriety of discounting and to deny any role to the state in safeguarding future generations. The rationale for discounting in this work lies in the notion that future generations are compensated through the growth of capital. Much of this work, however, relies on models that exclude the natural capital base from consideration, so that capital expenditures today appear to yield only growth benefits for the future. This is a highly misleading proxy for the growth potential of the entire system, which relies as much on natural capital as on produced capital.

The authority for ignoring the future costs of present activities stems from the structure of property rights. Under the existing system, environmental resources are not allocated on the basis of their full intertemporal opportunity cost. Rather, property rights tend to be such that resource users are confronted only by the direct costs of resource use, and can ignore the uncompensated costs that are imposed on the future, as well as those externalities that are imposed on the present. The issue of intergenerational compensation becomes more difficult when these uncompensated costs are discontinuous and uncertain. Thus, there is no way to estimate costs to the future directly, and there is no means to assign property rights to unborn generations. The net result is that future costs are only taken into consideration insofar as the present generation chooses to take an ethical responsibility for them. The precautionary principle merely confronts this reality.

Decision Making Under Incomplete Information and Under the Precautionary Principle

Decision making under risk occurs when there is a well defined set of possible outcomes. When it is not clear that an outcome will belong to the set of outcomes, or what the probability of that set is, then we have decision making under uncertainty. It is a characteristic of decision making under uncertainty that new information is acquired over time. Uncertainty typically occurs when there is no historical precedent for the activity or its impacts from which to gather data. As time passes and the historical record is enhanced, information will accumulate, thus pushing forward the boundary between the known and the unknown. Hence, the decision-making process will evolve sequentially in response to the changing information available to the decision maker. Decision makers will reserve judgment about uncertain outcomes (and act accordingly) until they are sure of their ground.

The class of problems for which the precautionary principle is advocated as an alternative to conventional decision-making models is that for which the level of uncertainty and the potential costs of current activities are both high. Global warming is one such example. Application of the precautionary principle in such cases involves a highly normative judgment about the responsibility of the present to the future - a judgment that can not be captured in existing models of rational decision making. The precautionary approach nevertheless accepts that every decision problem has elements of the standard problem. Uncertainty is treated as a residual - a property of the unobserved part of the system. The approach assigns a worst case value to the uncertain outcome of current activities. The optimal policy is then the one that minimizes the maximum environmental costs over variation in the unobserved part of the history of the system.

The link between the worst case scenario approach embodied in minimax and the precautionary principle seems quite obvious. The problem, however, is to define the worst case under conditions of incomplete information. It is not possible to select the worst case out of a known range of possibilities since that range remains unknown. Nor can we simply select the worst possible imaginable consequences, for it is always possible to envision apocalyptic scenarios. Such a construction would necessarily paralyze all activity. Since the worst case scenario must be believable enough to capture policy makers' attention in order to be operational, something else is needed.

Shackle's concept of the "focus loss" of a decision is a good starting point. A set of possible future states is projected in connection to any given action. An opinion is formed as to the degree of disbelief in the occurrence of each state - a measure of the potential surprise they would experience if this state actually came about. These outcomes are then ordered according to an attractiveness function that would register the power of each outcome to command the attention of the policy maker. Thus, low probability yet believable outcomes that would involve high costs will command attention (such as a Chernobyl type event), while catastrophic but barely believable outcomes of vanishingly small probability will be ignored. The central point here is that the "focus loss" of a decision is adopted as the point of reference in a decision process of "reserved rationality." Decision makers confronted by uncertainty will reserve their position on some outcomes, and pending receipt of additional data they will adopt policies that will minimize the worst believable case.

Under the precautionary principle, decision makers who are ignorant as to the magnitude of potential losses will proceed cautiously to safeguard against the possibility of unexpectedly severe future costs. This seems prudent in those cases where certain policies have the potential for destroying crucial life support systems. Under such conditions of uncertainty, it would also be prudent to allow some margin for error, precisely because the impacts are unknown. This approach provides a method for determining the future costs of potentially catastrophic outcomes, and thus a yardstick against which to measure the net benefits of committing preventative expenditures today. As new information accrues, the sequential decision-making process envisioned here will allow for adjustments in policy over time.

It is worth stating that a normative ethical set of judgments is necessarily embedded in these procedures, as the decision maker must attach relative weights to various outcomes and to the populations that may be affected. In particular, the issue of responsibility to the future is involved, for even if the possibility of future devastation seems quite remote, it may well be as unacceptable to pursue the causative activities as if that outcome was assured.