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Climate change mitigation policies typically call for very long-term investments, with current costs justified largely by the benefits to future generations. When evaluating such policies, economists use the techniques of cost-benefit analysis, including discounting of future costs and benefits. This essay reviews the standard economic approach to discounting as it applies to climate change, arguing that because there is no simple way to justify the choice of a discount rate for investments whose benefits and costs span several generations, collapsing those effects into a single number is highly misleading.

In the authors' view, the question of discounting these intergenerational impacts is closely connected to problems of fairness and distribution; cost-benefit analyses frequently rest on hidden and controversial assumptions about equity. The answer is to use the most sophisticated methods of economic analysis that display the distribution of costs and benefits both between nations and between generations.

Discounting and Intergenerational Equity

Climate change involves questions of risk and uncertainty, which pose unique problems for economic analysis. Many of the crucial outcomes are not only far in the future, but also subject to inescapably great uncertainty. If the degree of risk associated with each future possibility were known in advance, then potential outcomes could in theory be risk adjusted, or converted to "certainty equivalents," for purposes of cost-benefit analysis. However, this theoretical device cannot be used in practice, since the risks are rarely known. The modern literature on investment under uncertainty (real-options analyses) suggests a different approach: recognizing that additional information will become available over time, a sequential decision process can reject once-and-for-all choices in favor of single steps that reach only to the next decision point.

Cost-benefit analysis has traditionally relied heavily on a hypothetical compensation test. If the present value of net benefits from a project is positive, those who receive the benefits could hypothetically compensate those who incur the costs. There is a strong economic argument for rejecting most or all projects that fail this test.

The logic of the compensation test runs into difficulty when costs and benefits are separated by several generations. If we decide against investment in climate change mitigation now on the

grounds that other investments have higher returns, there is no way to compensate the future generations who will suffer as a result. Should we establish a global trust fund for future compensation, in lieu of climate change investments? Even if we could overcome the political obstacles to creation of such a fund, it would be impossible to commit intervening generations to maintain the trust fund for the far-future generations who will need it the most.

Conversely, if we do decide to invest now for the benefit of future generations, there is no way for them to compensate us today - as might seem equitable if we expect per capita incomes to be higher in the future. Intergenerational transfers happen all the time, but there is no mechanism that allows a planned reallocation across generations to offset the costs of an investment. In short, climate change investments involve redistribution of resources, a question that cannot be settled by cost-benefit analysis.

Optimal Growth and Discounting

In the selection of a discount rate for climate change analyses, economists have used two methods, which have been called the prescriptive and the descriptive approaches. Both approaches are invalidated in this application by flaws in their logic.

The prescriptive approach argues that, in a theoretical model of optimal economic growth, the discount rate would be the sum of two different components. One is the discount rate for utility, that is, the satisfaction produced by consumption: how much less is the same amount of happiness worth if it occurs in the future? There is widespread agreement that this should be zero; that is, an equal amount of human satisfaction should be valued equally regardless of when it occurs.

The other component of the discount rate reflects the expected growth of per capita income, and the accompanying expected change in the marginal utility of income: if we are richer in the future, will a dollar of additional income produce less satisfaction then than it does now? Empirical estimates of this component of the discount rate generally range from 0.5% to 3.0%.

One problem with the prescriptive approach is that it is derived from an economic theory of optimal growth which clearly implies that the discount rate should equal the rate of return on capital. Yet the return on capital is 5% or more, well above any of the prescriptive estimates of the discount rate. Therefore, contrary to the theory's assumptions, we are far from being on an optimal growth path.

Another problem is implicit in the assumption that human satisfaction is equally important in all time periods (i.e., the assumption that the first component of the discount rate must be zero). This assumption embodies a radical egalitarianism, which is not commonly applied in other contexts. People do not act as if everyone's satisfaction is equally important in the present; they do not give the same weight to the welfare of their own distant descendants as they do to themselves and their children; and even less do they act as if people living in distant countries many generations in the future should count equally with themselves in cost-benefit calculations. In short, a controversial, frequently violated ethical premise is buried in the analysis.

The alternative, descriptive approach takes the position that the observed marginal rate of return on capital should be used as the discount rate. This approach assumes that society's preferences about intertemporal transfers are revealed by current market rates of return, an assumption that avoids many of the problems of the prescriptive method. However, the discount rate in standard economic models is based on an individual's short-run trade-off between consumption now and at a moment in the near or medium-term future. There is no way to interpret this as the rate at which someone would trade consumption today for someone else's consumption two hundred years from now - since, as we have seen, there is no way to arrange compensation for such a trade.

Thus neither market data, in the descriptive approach, nor economic principles, in the prescriptive approach, leads to a justifiable discount rate that applies to intergenerational trade-offs. What role does this leave for economic analysis in determining climate change policy? In view of the difficulties with discounting, the costs and benefits of climate change policies should be displayed as time profiles, rather than collapsed into present values. Such profiles provide important information for decision-making, especially when contrasted to similar calculations for alternative investment scenarios. When comparing two scenarios, "any economist ... will obviously feel a strong urge to discount the difference in the consumption streams to a present value. But given the previous discussion, the corresponding value will be essentially meaningless." [80]

A focus on time profiles rather than present values can also help address the issue of risk and uncertainty. The goal is not to make a definitive yes-or-no decision on a multi-century endeavor. Instead, the sequential approach to decision-making under uncertainty suggests that we should gather the information that is relevant to a tractable planning horizon, perhaps 10 to 30 years, and plot a course of action that will allow us to move ahead with additional mitigation investments in the future if we choose to do so.

Concepts of Equity

Numerous issues of equity arise in connection with global climate change policies, either between nations, between generations, or both. Discount rate calculations mask the impacts of an investment on across nation or intergenerational equity. However, agreement on contemporaneous equity between nations may be a prerequisite for effective, future-oriented international action.

Since current conditions are viewed as inequitable by poor countries, wealthier nations may have to accept a greater share of the costs of forestalling climate change in order to gain broad participation in an accord. That distribution of the burden of climate change mitigation is consistent with one important concept of equity: benefits and costs should be shared in similar proportions. The idea of proportionality echoes the theory of economic efficiency, in which factor payments are proportional to marginal costs; it is also consistent with legal concepts of responsibility and the philosophical principle of "fault-based equity," and with the ecological "polluter pays" principle.

Equity in the present does not guarantee equity over time. Consistent behavior across generations cannot be guaranteed; future generations may choose different values. Once we act, posterity is in the driver's seat. With free choice and no intertemporal enforcer of values, contradictory behavior across generations is certainly possible.

The requirements for sustainability compound this dilemma, particularly for poor societies. To ensure sustainability we must both leave the resources needed by future generations, and provide the resources needed by the current generation. Ecologists emphasize the importance of slowing population growth as a way to guarantee sustainability. But this also poses a difficult equity question in the present: whose population growth will be curtailed? The major point here is that intergenerational equity has implications for intragenerational equity, and vice versa.

"The central conclusion of this chapter is that the mechanical application of the discounting apparatus to large-scale economic models cannot automatically lead to policy prescriptions for generation-spanning, global climate change-mitigating strategies that are equitable and therefore likely to be adopted. Nevertheless, economists' tools can provide tremendous insights into forging fair and efficient methods, policies, and institutions for dealing with global climate change." [94]