An eye on the future

Discounting

How economists' controversial practice of discounting really affects the evaluation of environmental policies.

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Decisions made today usually have impacts both now and in the future. But in carrying out policy evaluations to help decision-makers, economic analysts typically discount future impacts. In the environmental realm, many of the future impacts are benefits from policy-induced improvements. Thus, in the environmental-policy context, future benefits (as well as costs) are often discounted.

This is controversial, partly because discounting can seem to give insufficient weight to future benefits and thus to the well-being of future generations. But does it actually shortchange the future? As economists, we have often encountered scepticism about discounting, particularly from non-economists. Some of this scepticism seems valid, yet some reflects misconceptions about the nature and purpose of discounting. By examining here how discounting affects the evaluation of environmental policies, we hope to clarify this concept.

It helps to begin by considering the use of discounting in private investments. Here, the rationale stems from the fact that capital is productive — money earns interest. Consider a company deciding whether to invest $1 million in the purchase of a copper mine, and suppose that the most profitable strategy involves extracting the available copper three years from now, yielding revenues (net of extraction costs) of $1,150,000. Would investing in this mine make sense? Assume that the company has the alternative of putting the $1 million in the bank at 5% annual interest. Then, on a purely financial basis, the company would do better with the bank, as after three years it will have $1,157,625 ($\$1,000,000 \times (1.05)^3$), compared with only $1,150,000 if it invests in the mine.

Future returns

We compared these alternatives by compounding to the future the up-front cost of the project. It is mathematically equivalent to compare the options by discounting to the present the future revenues or benefits from the mine. Discounting offers a quick way to check whether the return on a project is greater or less than the interest rate by taking future revenues and translating them into present units, using the 'alternative rate of return' (the bank's rate of interest in our example) as the discount rate. So the discounted revenue in this case is $1,150,000 divided by $(1.05)^3$, or $993,413 — less than the cost of the investment. Thus, the project would not earn as much as the alternative of putting money in the bank. If the discounted revenue exceeded the cost of the project, then the project would yield a higher return than the bank, and the company would be better off investing in the mine.

This simple example suggests a general formula to determine whether an investment offers a return that is greater or less than the alternative of putting money in the bank. Suppose a project involves benefits (revenues) and costs over a time span from the present (time 0) to T years from now. Let B_t and C_t refer, respectively, to the benefit and cost t years from now, and let r represent the annual rate of return on a standard investment. The present value of the net benefit (PVNB) is given by

$$\mathrm{PVNB} = \sum_{t=0}^{T}(B_t - C_t)/(1+r)^t$$

If this value is positive, the project will yield a return that is higher than the market interest rate.

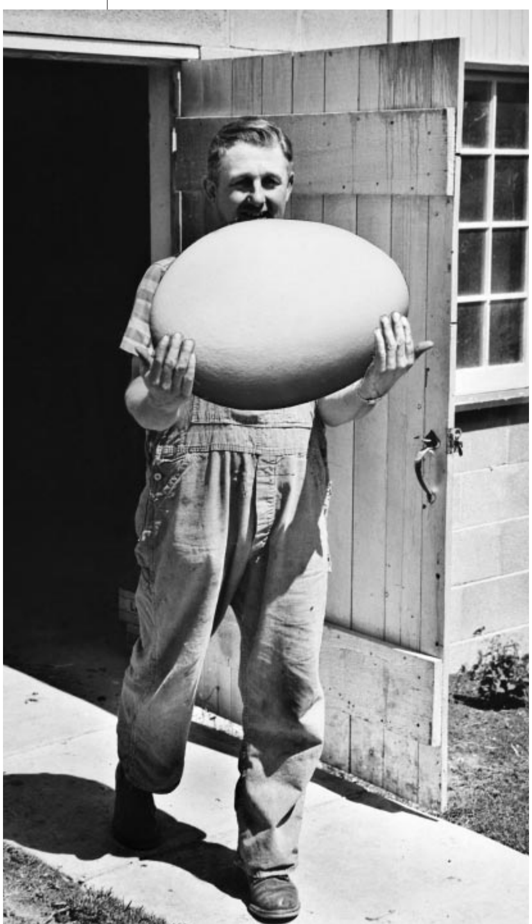
Discounting translates future sums of money into equivalent current sums; it undoes the effects of compound interest. It is not aimed at accounting for inflation, as even if there were no inflation it would still be necessary to discount future revenues to account for the fact that a dollar today translates (through interest) into more dollars in the future.

Sums for society

Can the same kind of thinking be applied to investments made by the public sector for the benefit of society? Consider the following hypothetical public-sector investment: a potential climate policy. Our purpose is to convey key issues in the starkest terms, so we will intentionally oversimplify some aspects of what follows. Suppose that a policy, if introduced today and maintained, would avoid significant damage to the environment and human welfare 100 years from now. The 'return on investment' is the avoidance of future damage to the environment and to people's well-being. Suppose that this policy costs $4 billion to implement, and that this cost is borne in its entirety today. Suppose also that the beneficial impacts — avoided damages to the environment — will be worth $800 billion to people alive 100 years from now. Should the policy be implemented?

The answer will depend, of course, on the evaluation criteria used. Consider first the criterion of whether the winners have the potential to compensate the losers and still be no worse off. For this condition to be met, the benefit to the winners, after being translated to equivalent dollars, needs to be larger than the losses of the losers. After compensation from winners to losers, the policy would yield what economists call a 'Pareto improvement': some individuals would be better off, and no individual would be worse off.

Are the benefits great enough that the winners could potentially compensate the losers and still be no worse off? Here, discounting is helpful. If, over the next 100 years, the average rate of interest on ordinary investments is 5%, a gain of $800 billion to people 100 years from now is equivalent to $6.08 billion today. (Equivalently, $6.08 billion today, compounded at an annual interest rate of 5%, will become $800 billion in



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Laying a golden egg? Discounting allows potential investors to weigh up their potential returns.

100 years.) The project satisfies the principle of potential compensation if it costs the current generation less than $6.08 billion.

Because the up-front cost of $4 billion is indeed less than this figure, the benefit to future generations is more than enough to offset the cost to the current one. More generally, a positive PVNB means that the policy has the potential to yield a Pareto improvement. More realistic policies involve costs and benefits that occur at all points in time. For these policies, discounting serves the same purpose, as we convert costs and benefits from various periods into their equivalents at a given time (such as the present, for example).

Applying a discount rate does not mean giving less weight to the welfare of future generations. Rather, the process simply converts the (full) values of the impacts that occur at different points of time into common units. In our example, the full benefit to future generations is translated into a current monetary sum, which then allows us to compare this benefit with the full cost to the present generation.

Winners and losers

Even if one accepts the idea of discounting as a mechanism to translate impacts into equivalent monetary units, one might be uneasy about PVNB analysis, which is based on the potential Pareto improvement (PPI) criterion — whether the winners from a given policy could compensate the losers and still be better off. If a policy's benefits exceed its costs, and compensation is introduced so that no one is worse off, then the attractiveness of the policy seems clear. But if compensation is not actually made, the appeal seems considerably weaker.

In our climate-policy example, discounted benefits to future generations will exceed the loss to the current generation, so the potential exists for a Pareto improvement — the PPI criterion is met. But if future generations do not actually compensate the present one, is it still appropriate to enact the policy? Perhaps so, but many would argue that if actual compensation cannot be made, a positive PVNB has less merit as an evaluation criterion.

Suppose a proposed climate policy fails the PPI test — the future benefits are not large enough to offset current costs. Do current generations nevertheless have an obligation to undertake the policy? They might. The PPI criterion deserves to be given weight, but in almost all policy evaluations — especially when compensation is not actually carried out — it is important to consider other evaluation criteria, as there are bound to be some cases in which there are compelling reasons for adopting a policy even when the PPI criterion is not satisfied, or for rejecting a policy even when it is.

Should a lower discount rate be used to incorporate considerations of intergenerational equity more fully in the PVNB calculation? Suppose that, when the market interest rate is used for discounting, a policy that would benefit future generations fails to generate a positive PVNB. Using a lower discount rate would give greater weight to future benefits (and costs), possibly making the PVNB positive. Such adjustments are problematic, however: they blur the distinction between the PPI (efficiency) criterion and other legitimate policy-evaluation criteria, such as distributional (in this case, intergenerational) equity. In evaluating policies, it seems better to use the market interest rate so that the PVNB calculation provides a meaningful indication of whether the PPI criterion is satisfied, while at the same time judging intergenerational fairness by direct examination.

Even if one accepts the use of the PPI criterion and discounting in principle, estimates of PVNB are necessarily imprecise. There is uncertainty about the denominator — the discount rate. Theoretically, this should reflect the market interest rate but, of course, future market rates are impossible to predict. There is also considerable uncertainty about the elements in the numerator — the benefits and costs that current and future generations will experience from a policy that is introduced today. This uncertainty is derived both from scientific uncertainty about the biophysical impacts of policies and from uncertainty about future generations' tastes and preferences — how much they will value the biophysical impacts.

Much scepticism about discounting and, more broadly, the use of benefit–cost analysis, is connected to these uncertainties. Consider the difficulties of ascertaining, for example, the benefits that future generations would enjoy from a regulation that protects certain endangered species. Some of the gain to future generations might come in the form of medical products (such as serums or vaccines) derived from the protected species, but such future impacts are impossible to predict. Moreover, benefits reflect the value that future generations will attach to the protected species — the enjoyment of observing them in the wild or just knowing of their existence. But how can we predict future generations' values? Economists and other social scientists try to infer them through surveys (such as the contingent valuation method) and by inferring preferences from individuals' behaviour. But these approaches are far from perfect, and at best they indicate only the values or tastes of people alive today.

The uncertainties are substantial and unavoidable. They do not invalidate the use of discounting or benefit–cost analysis, but they do oblige analysts to acknowledge them in their policy evaluations. It is crucial to evaluate policies using a range of values for discount rates and for future benefits and costs. We should have less confidence in a project for which the sign of the PVNB is highly sensitive to the discount rate or to small changes in projected future benefits and costs, compared with a project with a PVNB that is not very sensitive to these elements.

The discounting debate

The application of discounting to environmental-policy evaluation is controversial, partly because of misunderstanding outside the economics community of what discounting actually does, which is to translate the values of future impacts into equivalent values in today's monetary units. The PPI criterion, which provides the rationale for discounting and calculation of the PVNB, deserves weight in evaluating environmental policies, although it is also important to consider other criteria (such as distributional equity), especially when the potential harm to 'losers' is substantial. Moreover, it is crucial to acknowledge any uncertainties about benefits, costs and interest rates. Some may argue that these complications invalidate PVNB calculations, but in our view such calculations — when carefully executed and thoughtfully interpreted — can provide useful information for making environmental-policy decisions. ■

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FURTHER READING

Arrow, K. J. *et al.* in *Climate Change 1995: Economic and Social Dimensions of Climate Change* (eds Bruce, J. P. *et al.*) 125–144 (Cambridge Univ. Press, 1996).
Arrow, K. J. *et al. Science* **272,** 221–222 (1996).
Fullerton, D. & Stavins, R. *Nature* **395,** 433–434 (1998).
Portney, P. R. & Weyant, J. P. *Discounting and Intergenerational Equity* (Resources for the Future, Washington DC, 1999).
Weitzman, M. L. *J. Environ. Econ. Management* **36,** 201–208 (1998).