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ENERGY AND ENVIRONMENT IN THE LONG TERM

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Abstract

An interesting feature of many of the environmental impacts of energy production and consumption is that they may be of very long duration--indeed are, for all practical purposes, irreversible. Particular attention thus needs to be given to ways of evaluating distant future impacts, dealing with the uncertainty that inevitably arises, and possibly even restructuring the welfare-theoretic basis of the analysis. A review of recent analytical developments indicates a series of adjustments that have the effect of increasing the present value of the costs of such impacts, making the responsible energy activities less desirable from the standpoint of economic efficiency.

Key words: energy, environment, long run.

Abbreviated Title: Energy and Environment in Long Term.

ENERGY AND ENVIRONMENT IN THE LONG TERM

An interesting feature of many of the environmental impacts of energy production and consumption is that they may be of very long duration--indeed are, for all practical purposes, irreversible. Particular attention thus needs to be given to ways of evaluating distant future impacts, dealing with the uncertainty that inevitably arises, and possibly even restructuring the welfare-theoretic basis of the analysis. In this paper I offer some thoughts on these issues under the headings of (1) the choice of discount rate, (2) alternative welfare criteria, and (3) the choice of a money measure of welfare change. I first give some examples of the kinds of environmental impacts I have in mind.

Irreversible Impacts

Two examples, well known from current discussions about the environment, can illustrate the complexities and the significance of processes that give rise to what I have called irreversible impacts. The first is acid rain, resulting from the combustion of fossil fuels. Let us consider the possible impacts on forests. Destruction of forests leads to erosion of topsoil, making revegetation more difficult. Further, if the destruction is on a large enough scale, it can trigger changes in climate--colder winters, hotter and drier summers.[1] These changes, often characterized as "desertification," in turn make more difficult the task of re-establishing a forest. In addition to the physical changes, the chemistry of the soil can be altered; acid rain leaches essential nutrients like sodium, potassium, and calcium.[2] In this scenario, an initial disruption triggers a sequence of changes that in turn make it difficult or impossible to undo.

A second example is the threat of species extinction. Again, the process is indirect. That is, the major threat is not overexploitation, but habitat modification. This can take several forms, including chemical pollution, as from acid rain, and direct conversion, as when tropical forests are chopped down for fuel.

The Choice of Discount Rate

One reason why these types of impacts are interesting is the challenge they pose to our notions of equity, or the way in which welfare is distributed across generations. And perhaps the most obvious way of thinking about this issue is by considering the choice of a discount rate used to translate future impacts into the present values that presumably guide current decisions about resource use. The literature on the choice of a social discount rate, the rate that "ought" to be used in a social decision, is vast, and I shall not attempt to add much here (for a detailed discussion involving environmental considerations, see Markandya and Pearce[3]). There are, however, a couple of points I wish to make.

The first is that there is some presumption (in my judgment, based on a review of the literature) that the appropriate social rate is below the private market rate. The second is that the use, by a public agency, of a below-market rate to evaluate an energy development project that is expected to have a long-lasting or even irreversible impact on the environment need not make the project less likely. For this to happen, it is crucial that the benefits and costs are counted correctly; in particular, that the environmental costs are counted. The second point needs no elaboration. The first is perhaps controversial, and I shall briefly indicate the reasons for my view.

Of the many arguments that have been advanced in support of the proposition that the social discount rate is below the private market rate (and, for that matter, that it is not), two seem worth taking seriously, as both theoretically correct and perhaps empirically important. One, due to Marglin,[4] is that the welfare of future generations is a public good to members of the present generation and that, therefore, the present generation, acting collectively, would wish to invest more (implying a lower discount rate) than the simple aggregation of investments made by individuals acting in isolation. Note that the argument is *not* that the present generation wishes, or ought to wish, to shift consumption to future generations on grounds of equity, or fairness. Rather, it is that such a redistribution would be desired by the present generation on the conventional grounds of efficiency, as perceived solely by the present generation. The point is that an allocation of resources dictated by the efficiency criterion has a distributional implication. Note, too, the importance of counting environmental costs of an investment in this case. A lower discount rate would tend to make a project with a heavy future environmental impact *less* likely--a result presumably not anticipated by Marglin in 1963 when the external, environmental costs of a project were typically not considered.

A second argument for a social discount rate below the private market rate is that the collective or social treatment of uncertainty about the costs and benefits of an investment is properly different from the private. Two reasons have been advanced in support of this view. One, due to Samuelson[5], is that acting collectively, say through a public agency, individuals are able to pool the risks associated with uncertainty about a very large number of different investment projects. As long as each has a positive expected present value, the law of large numbers assures that the expected present value of the aggregate will also be positive. The other reason, due to Arrow and Lind,[6] is that the risk attached to any one investment undertaken publicly is spread over a very large number of individuals (all taxpayers?) and that the sum of the individual risk premiums vanishes in the limit, leaving a riskless discount rate that is less than the market rate, which factors in the riskiness of the investment. The result that the sum of individual risk premiums vanishes is not at all obvious and is, indeed, the subject of a complicated proof. A question has also been raised about whether both risk pooling and risk spreading are not, in fact, achieved in a stock market economy. Clearly they are, to a degree. The question is whether they are "fully" achieved. My sense is that they are not (see Leland[7]).

Thus far, I have made a theoretical case for the proposition that the social discount rate is below the market rate. But the theory does not have sufficient content to shed any light on the question of how much below. Nor is there an empirical basis for an answer. As a practical matter, I would recommend the use, in a social benefit-cost analysis, of a plausible measure of the market rate for a given type of investment, and then carry out sensitivity analyses with a range of discount rates below the market rate.

Alternative Welfare Criteria

Much the same effect (as that produced by a below-market discount rate) on the evaluation of a project having a long-lasting impact on the environment arises from an adjustment that takes account of what has been called quasi-option value.[8] This is essentially the value of information about uncertain future impacts conditional on not taking the irreversible step in the present. Less precisely but more intuitively, it is the value of retaining an option to enjoy an environment expected to yield positive but uncertain benefits in the future. Given information, or a willingness to make assumptions about the probability distributions of both project and environmental benefits, it is possible to calculate precisely the magnitude of the needed adjustment. In some illustrative examples the adjustment is a substantial percentage--perhaps as much as 50 percent--of the values estimated in a conventional benefit-cost analysis.[9,10] The adjustment is subtracted from the expected net benefits of the project, making it less likely to pass a benefit-cost test.

Strictly speaking, this procedure perhaps does not represent a change in welfare criteria. An approach that clearly does represent such a change is the following. Suppose we are considering an energy scenario that carries a risk of potentially catastrophic accumulation (as for example, of greenhouse gases such as the carbon dioxide produced by burning fossil fuels) or release (as for example, of radioactive materials produced by nuclear fission). In such a scenario, we may not wish to use benefit-cost analysis at all, even with low discount rates and even adjusting for uncertainty. The reason is that this applied welfare analysis rests on certain assumptions, in particular on the assumption that demand and supply and, hence, prices in other sectors (than the one under consideration) are not affected. A truly catastrophic event would render this assumption invalid and ought perhaps to lead to a different decision criterion. One such is derived from the work of Rawls,[11] in which welfare is judged solely by the impact on the worst-off individual or, in this case, generation. The implied social welfare function is what is known as "maxi-min": $W = \min(U_1, U_2, \ldots, U_n)$, and $\max W = \max[\min(U_1, U_2, \ldots, U_n)]$, where W = welfare, and U_i = i's utility. In essence, the idea is that welfare is not additive over individuals, or generations, with or without discounting or adjustments for uncertainty.

The Choice of a Money Measure of a Welfare Change

The final issue I wish to consider is the choide of a consumer surplus measure of the value of an environmental impact. Normally, in applied welfare analyses, we use the compensating variation (CV) measure: the income that an individual would be willing to give up in exchange for some benefit or would require in compensation for some loss. For example, when we consider the restoration of a hazardous waste site--a process that may require many years, or even decades--we implicitly use CV to measure the costs: the income required by the owners of labor services, materials, and machinery used in the restoration to induce them to provide these items. I would argue that consistency obliges us to use the same CV measure for nonmarketed environmental services. That is, in assessing damages to the environment, we want to elicit an amount of money that would be required to compensate people for bearing the damage. We are interested in their willingness-to-*accept* (WTA) rather than their willingness-to-*pay* (WTP).

Theoretical welfare analysis has demonstrated that the difference between WTA and WTP for evaluating *price* changes depends on an income effect and will normally be small.[12] More recently, it has been shown that the situation is more complicated for a change in quantity or quality, such as the supply of environmental amenities or an index of their quality.[13] It turns out that a substitution effect--the elasticity of substitution between the environmental good, on the one hand, and any or all of the available private market goods, on the other--also affects the difference between WTA and WTP. In particular, if this elasticity is low, the difference can be substantial--indeed, as substantial (up to an order of magnitude) as empirical results have suggested. This presents something of a problem for the analyst since WTP is normally more easily and more reliably measured. But if it is appropriate to use CV, which in this case implies WTA, then at a minimum the analyst needs to acknowledge that an estimate of damages based on WTP will be an underestimate, and perhaps by a large margin.

Although this is not explicitly a dynamic issue, there is an interesting and potentially empirically important dynamic twist. If it is true, as Krutilla[14] originally suggested, that substitution possibilities for the natural environment are becoming less good over time (perhaps as a consequence of changing preferences), then the disparity between WTA and WTP will be larger in the future than it is now, or has been in the past. In assessing an energy alternative net of its environmental costs, we can expect that the present value will be reduced by the increasingly larger WTA measure of those costs.

Concluding Remarks

I have reviewed several considerations special to the welfare analysis of energy activities expected to have very long-lasting, perhaps even irreversible, impacts on the environment. For each, the policy implication that emerges is to go slow, be conservative, in the sense that indicated adjustments to a conventional benefit-cost analysis effectively increase the present value of the activities' costs. This result follows from a focus on efficiency in resource allocation, not from any special concern for the distribution of welfare across generations--though the distributional implications are profound.

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