DISCOUNTING AND SUSTAINABILITY

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1993, *Review of Marketing and Agricultural Economics* 6(1), 161–64.

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The discounting of future benefits has long been one of the most controversial, and in many ways, unsatisfactory, aspects of benefit cost analysis. This concern has been heightened by the rise of the environmental movement and, particularly by the debate over sustainable development. The sustainability approach is presented as an alternative to the standard benefit–cost analysis approach to the question of inter-generational equity.

Sustainability is in fashion, and, as with all fashionable terms, it has been used in many ways and in support of many different policy agendas. A summary and critique of the literature is given by Lélé (1991). I shall interpret sustainability very broadly to encompass two main concerns:

(i) The interests of future generations should be given equal weight with our own in making decisions affecting the long term future;

(ii) It should not be assumed that capital (that is, technology embodied in produced goods) can be substituted indefinitely to compensate for land (taken broadly to include all the contributions of the natural environment to human welfare, and agricultural production in particular.

In this paper, the relationship between the idea of sustainability and the older literature on optimal growth is examined and implications for discounting, income distribution and the treatment of uncertainty are explored.

Optimal growth and development theory

The problem of planning growth in a manner that satisfies condition (i) above was posed by Ramsey (1928), who sought to determine the pattern of growth of the capital stock that would maximise aggregate utility. If utility is assumed logarithmic and additively separable, a straightforward application of optimal control theory yields the *Ramsey rule of saving:*

The marginal productivity of capital should be equal to the rate of growth of consumption.

Ramsey rejected, on the same ethical grounds that give rise to condition (i) above, the discounting of future utilities. This has fundamental implications for the nature, and interpretation, of the solution.

An important implication of the Ramsey rule is that, even though the problem formulation does not involve any discounting of future welfare, the marginal rate of time preference (or, equivalently, the opportunity cost of capital) is not, in general, zero. Under appropriate conditions, the growth path derived from the Ramsey rule will converge to a ‘golden rule’ path in which output, consumption and capital stock attain their maximum sustainable levels. There is a close analogy between the ‘golden rule’ path and the concept of ‘maximum sustainable yield’ for fisheries and other renewable natural resources.

The basic result may be illustrated in Figure 1. Here the *x* axis represents the stock Z and the y-axis represents either the rate of return to capital, or the rate of renewal of a natural resource. Under the Ramsey solution, the optimal path leads to the point $\tilde{Z}$. By contrast, if the discount rate is positive, the optimal solution will be either convergence to a tangency point such as Z* or, if the discount rate is sufficiently high, to exhaustion of the stock and an equilibrium at zero.

It is a straightforward matter to extend the Ramsey rule analysis to incorporate two separate stocks - a human produced capital stock and a stock of renewable natural resources. Assuming no substitution between these stocks and in the absence of harvest costs, the optimal rule for the stock of renewable natural resources is a path leading to the maximum sustainable yield. As Dasgupta and Maler (1990) observe, much more complex versions of the problem may also be solved using the central control-theoretic tool of the current-value Hamiltonian.

In particular, it is possible to address issues of uncertainty and income distribution, which have usually proved intractable in benefit–cost analysis. The critical result for the treatment of uncertainty is that the desirable opportunity cost rate of discount is endogenous. From the Ramsey rule, the opportunity cost rate is lower, the lower is the rate of growth of consumption. In particular, if future consumption is lower than present consumption, the opportunity cost rate is negative. This means that project appraisals should be weighted to favor projects that yield high payoffs in adverse states of the world. Similarly, the explicit use of a utilitarian framework implies the direct incorporation of income-distributional concerns into the objective function.

The sustainability literature

A different approach has been taken in the mainstream literature on sustainable development (Pearce 1987; Barbier 1987). The reasons for this divergence may be traced to the economic crisis of 1973 which saw both the end of rapid economic growth in the developed countries and the rise of concern about the exhaustion of natural resources associated with the dislocation of world commodity markets, of which the most dramatic expression was the rise of OPEC.

All of this led to a positive climate for the publication of *The Limits to Growth* (Meadows et al 1972), a work devoted to the argument that unless economic growth was stopped, disaster, in the form of resource depletion and environmental collapse was inevitable. The centerpiece of *The Limits to Growth* was a ‘world model’ incorporating exponential growth and a number of feedback processes. It included estimates of exhaustion dates for the key resources used in industrialised societies. (The most extreme projections had metals such as lead, mercury and copper being exhausted in the 1990s.)

Despite its technical inadequacies, *The Limits to Growth* fundamentally altered the terms of the resources debate. Critics such as Robinson (1975, p. 55) demolished naive concerns about resource depletion, but concluded that “if one is looking for ‘physical limits’ to growth it is likely that the earth’s capacity to assimilate wastes will become a constraint before there is any question of ‘running out of energy.’” The *Limits to Growth* debate also raised the possibility that future generations might be worse off than ourselves in significant ways. These issues have driven the debate over sustainability.

Solow (1974) drew on the (then) recent work of Rawls (1971) to consider the implications of a maximin criterion for intergenerational equity. The most obvious implication is that consumption should be constant over time. Otherwise the maximin criterion can be increased by reducing the consumption of all but the worst-off generation in order to benefit that generation. More precisely, consumption should be set at the maximum feasible constant level.

Hartwick (1977, 1978) examined the implications of this position in a model in which man-made and natural capital could be substituted. Hartwick showed that the maximin criterion would be satisfied if the rents from depletion of natural capital were invested in human capital.

Advocates of the use of sustainability criteria, most notably Pearce and his co-workers, have argued that the Solow-Hartwick constraint, that capital stocks not be reduced, should be applied to stocks of environmental capital on an individual basis, rather than to the aggregate of natural and man-made capital. Barbier, Pearce and Markandya (1990) propose an extended form of benefit–cost analysis incorporating this 'sustainability' constraint. Subject to this constraint, the benefit–cost analysis criterion they propose is the standard one of maximizing the net present value of consumption, at the market discount rate. The market discount rate will, in general, be higher than the optimal rate endogenously derived from the Ramsey rule. The effect of the sustainability rule is to impose an additional constraint on the optimisation problem, which may be captured by a shadow price associated with the benefit from relaxation of the constraint.

The use of a sustainability constraint will generally yield results inferior to those arising from application of the Ramsey rule. There are several reasons why an optimal solution of this kind might not be adopted. First, few governments now attempt central planning and most make only indirect attempts to control the level of aggregate savings and investment. Second, the determination of the optimal solution requires a complete valuation of the services of the resources, and only limited progress has been made in this direction. Finally, questions of sustainability are of particular interest to lending agencies such as the World Bank, which must, in many cases, evaluate individual projects, while taking the overall settings of national economic policy as given.

In these circumstances, it may be desirable to use the market rate of interest r and impose 'rule-of-thumb' sustainability constraints that partially compensate for the excessive discounting of future welfare. If the unconstrained optimal solution calls for a final $Z^* > Z_0$, the sustainability constraint will not be binding. If the unconstrained optimum has $Z^* < Z_0$, the sustainability constraint is binding in every period and the solution is $Z_t = Z_0, \forall t$. The use of the sustainability constraint is equivalent to replacing the discount rate r with $\min(H'(Z_0), r)$.

The imposition of the sustainability constraint must increase welfare, according to the classical utilitarian objective function, whenever $Z_0 \leq \tilde{Z}$. The imposition of the constraint will reduce welfare for sufficiently large $Z_0 > \tilde{Z}$. In particular, when $Z_0 = \bar{Z}$, the constraint forbids any harvesting of the resource. Since this version of the problem is based on the assumption that the stock *per se* has no social value, the constraint is clearly inappropriate in this case.

From the discussion above, it is possible to derive a modified constraint which will always increase the value of the classical utilitarian welfare function relative to the unconstrained competitive optimum. The modified constraint requires that if the initial stock is greater than the level $\tilde{Z}$ that generates the maximum sustained yield, the stock should be driven down to $\tilde{Z}$ along the path satisfying the Ramsey rule. Thereafter maximum sustained yield should be maintained. If the initial stock is less than $\tilde{Z}$ then the sustainability rule should be applied.

The modified constraint proposed here will not, in general, yield the optimal outcome. However, it produces a strict improvement in welfare relative to the usual sustainability constraints whenever the two differ. That is, whenever $Z_0 > \tilde{Z}$, the level of harvest is greater in every period under the modified constraint.

In summary, the examples discussed above represent simple cases in which the application of the market rate of discount may yield an outcome that is both unsustainable and, from a utilitarian viewpoint, sub-optimal. It has been shown that, in most cases, the imposition of a sustainability constraint will improve welfare, although it will not yield the optimal outcome.

Concluding Comments

The recent literature on sustainability has been sharply criticised by Dasgupta and Maler (1990) as an inferior substitute for the theory of optimal development. The present paper has been formulated within an optimal development framework. It has been motivated by Solow's suggestion that sustainability criteria may represent workable rule of thumb approximations to optimal policies in cases where the discounting criteria used in benefit–cost analysis involve inadequate concern for future generations. It is shown that in the simplest case of exploitation of a renewable resource under certainty, the imposition of sustainability criteria will usually lead to an improved outcome.

Sustainability criteria are not the only rules of thumb used in benefit cost analysis Issues of income distribution are frequently handled using distributional weights. Adjustments to discount rates are used to account for uncertainty. Each of these approaches has been the subject of a large literature, and neither can be regarded as entirely satisfactory. In this paper, the analysis of sustainability as a rule of thumb has been extended to suggest a consistent treatment of all of these issues.

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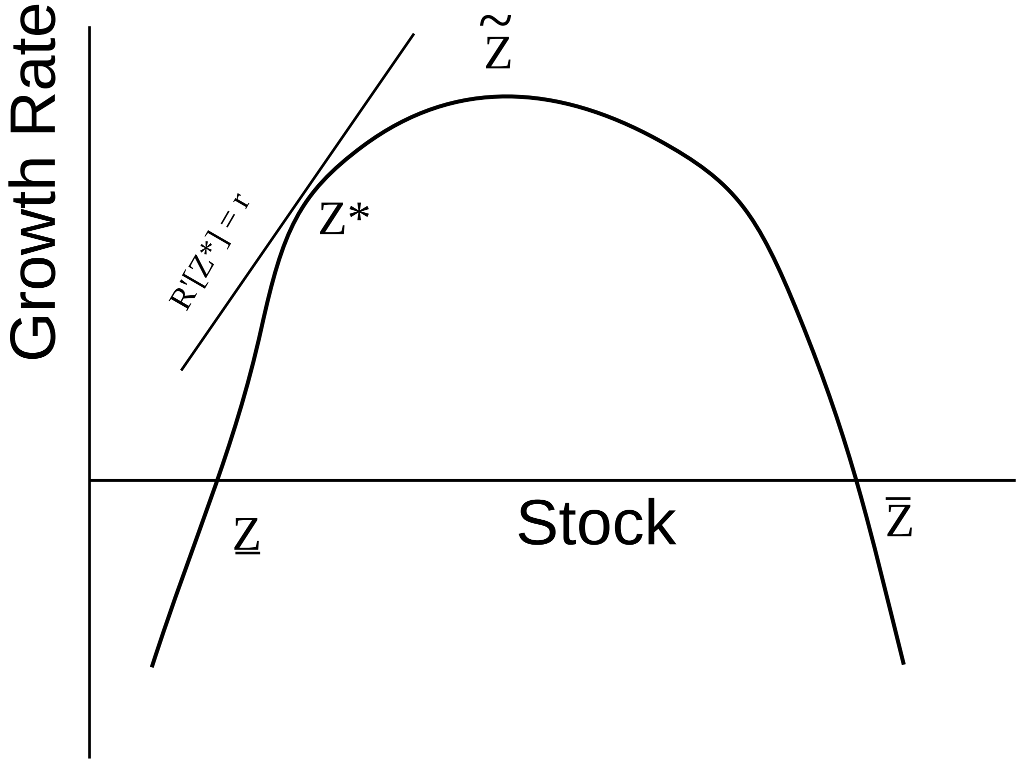

Figure 1: Growth of a renewable resource
(Heal and Dasgupta)