VIEWPOINT: WEAK VERSUS STRONG SUSTAINABILITY

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Abstract

The meaning of sustainability is the subject of intense debate among environmental and resource economists. Perhaps no other issue separates more the traditional economic view of the natural world from the views of most natural scientists. The debate currently focuses on the substitutability between the economy and the environment or between "natural capital" and "manufactured capital"-- a debate captured in terms of "weak" vs. "strong" sustainability. In this paper the various interpretations of these concepts are examined. In addition, the goal of weak sustainability is critically evaluated. Attention is devoted to, among other things, utility and lexicographic preferences, economic valuation, natural science perspectives on sustainability, and the notion of "consilience" as recently suggested by E.O. Wilson.

1. Weak Sustainability

The meaning of sustainability is the subject of intense debate among environmental (and resource) economists. Perhaps no other issue separates the traditional economic view of the natural world from the views of most natural scientists. The debate currently focuses on the substitutability between the economy and the environment — or economic goods and services, or "natural capital" and "manufactured capital" —, a debate captured in terms of "weak" vs. "strong" sustainability. According to Brekke (1997):

" A development is … said to be *weakly* sustainable if the development is non-diminishing from generation to generation. This is by now the dominant interpretation of sustainability." (Italics added).

Dominant, that is to say, among economists, not ecologists and most other natural scientists. In economic growth theory sustainable development is often translated into intergenerational equity. This is usually interpreted as a constraint on growth, namely non-decreasing welfare (Pezzey 1989, 1992). This can be interpreted as non-decreasing welfare over time in single-generation models, or non-decreasing welfare over generations in discrete-generation models. This is quite a strict criterion, as any temporary decrease in welfare implies unsustainable development. Pezzey has referred to "sustainedness" in this respect, since such a pattern can be assessed only after the fact. As a weaker alternative criterion, Pezzey also refers to "survivability" which allows a reduction of welfare as long as the level of consumption exceeds some subsistence level.

In the general case, of course, (social) welfare is a function of utility, which is difficult to operationalize. In practice, simple models often equate utility with aggregate consumption, defined as gross output less investment ("Hicksian sustainability"). Maximizing happiness is equated with maximizing consumption. In principle, consumption would have to be interpreted in the general sense, to include environmental goods and services. However, consumption in such models is likely to be interpreted, in practice, in terms of *produced* goods and services, leaving out goods and services provided by the environment. The same problem applies also to the more general concept of utility. We return to this issue subsequently.

Another interpretation of economic ‘development’, underlying Brekke’s definition above, refers to continuing growth of Net National Product (NNP). This is defined as Gross National Product (GNP) minus capital consumption, or capital allowance, (to replace depreciation). GNP is commonly seen as total output of goods and services by the economy. It is often interpreted as the sum of returns to the factors of production, namely labor and capital stock.

Thus, sustainability is basically seen by neoclassical economists as a problem of managing a nation’s portfolio of capital to maintain it at a constant level, either *in toto* or *per capita*. It includes natural capital, in principle, but it also allows for virtually unlimited substitution between man-made and natural capital (see Pearce *et al.*, 1990). Common and Perrings (1992) have coined this “Hartwick-Solow sustainability” (see Hartwick, 1977; and Solow, 1986). Note that “Hicksian sustainability”, which requires non-decreasing consumption — including consumption of environmental goods and services — is virtually equivalent to "Hartwick-Solow sustainability” defined in terms of maintaining the total capital stock of society.

An operationalized version of Hicks-Hartwick-Solow weak sustainability has been suggested by Pearce and Atkinson (1995). It reduces to the following formula for countries:

$$Z = S/Y - d_M/Y - d_N/Y \ ,$$

where Z is an index of sustainability, Y is GNP, S is (national) savings, d_M is the rate of depreciation of man-made capital and d_N is the rate of depreciation of natural capital. An economy is weakly sustainable if $Z > 0$.

The economic perspective on weak sustainability, then, is that of an individual-acting-at-a-point-in-time, nation-wide or even planet-wide, “portfolio manager”. The practical expression of this has been to focus attention on providing equal opportunities for present and future generations. Neoclassical models fit this perspective quite well, by using the standard methodology of dynamic optimization to generate utility patterns over time. Although having different starting points, “intergenerational equity” and “weak sustainability” can lead to similar conclusions, as long as gross economic output or gross consumption are accepted as proxies for welfare.

Weak sustainability implicitly assumes, of course, that savings are invested in manufactured capital or human capital and that the latter are perfectly substitutable for natural capital. Furthermore, levels are irrelevant, only changes matter. Countries with a history of resource depletion and ecosystem damage may look sustainable. Indeed, numerical results in Pearce and Atkinson show that this is the case for the Netherlands and Japan, both of which have hardly any forest land. This hints at the problem of sustainability of open regions or countries, which evidently can surpass local sustainability limits by entering international trade. Indeed, one may ask whether trade can substitute for nature? For more discussion of weak sustainability see Cabeza-Gutés (1996). The issue of regional or national sustainability, and sustainable trade, have hardly been touched upon (see van den Bergh and Verbruggen, 1998).

An instructive example of extreme implications of weak sustainability in practice is the small Pacific island nation of Nauru (Gowdy and McDaniel 1999, McDaniel and Gowdy 1999). In 1900 one of the world's richest phosphate deposits was discovered on Nauru and today, as a result of just over ninety years of phosphate mining, about 80 per cent of the island is totally devastated. At the same time, the people of Nauru have had, over the past several decades, a high per capita income. Income from phosphate mining enabled the Nauruans to establish a trust fund estimated to be as large as $1 billion. Interest from this trust fund should have insured a substantial and steady income and thus the economic sustainability of the island. Unfortunately, the Asian financial crisis, among other factors, has wiped out most of the trust fund. The people of Nauru now face a bleak future. Their island is biologically impoverished and the money Nauruans traded for their island home has vanished. The "development" of Nauru followed the logic of weak sustainability, and shows clearly that weak sustainability may be consistent with a situation of near complete environmental devastation. This case illustrates a telling argument against weak sustainability. A substitution of natural for manufactured capital may be one-way: once something is transformed into manufactured capital there is no way to return to the original situation.

2. Strong Sustainability

The alternative to weak sustainability is strong sustainability. In Brekke's words:

"The second interpretation, known as 'strong sustainability', sees sustainability as non-diminishing life opportunities (see Page 1983 or Daly and Cobb 1989, p. 72). This should be achieved by conserving the stock of human capital, technological capability, natural resources and environmental quality" (Brekke 1997 p. 91).

Under the strong sustainability criteria, minimum amounts of a number of different *types* of capital (economic, ecological, social) should be independently maintained, in real physical/biological terms. The major motivation for this insistence is derived from the recognition that natural resources are essential inputs in economic production, consumption or welfare that cannot be substituted for by physical or human capital. (A second possible motivation is quasi-moral, namely acknowledgment of environmental integrity and `rights' of nature. We discuss it below). In either case it is understood that some environmental components are unique and that some environmental processes may be irreversible (over relevant time horizons).

"Very strong" sustainability — like supported by the Deep Ecology movement and those who believe in the 'right-to-life' of other species — would then imply that every component or subsystem of the natural environment, every species, and every physical stock must be preserved (see Pearce and Atkinson, 1995). This seems impossible, again for two if not three reasons. The first is probably sufficient: the dependence of our current industrial economy on primary resources. The second problem is that species and ecosystems are subject to continuous processes of natural change, and while human activity accelerates some of these processes and inhibits others, humans are — at the end of the day — a part of nature. A third problem is legal and philosophical: if other species have absolute rights, as argued by some, those rights must contradict other rights, especially property rights, that are already enshrined in law and custom.

A compromise version of strong sustainability focuses on ecosystems and environmental assets that are critical in the sense of providing unique and essential services (such as life-support) or unique and irreplaceable non-use values. The ozone layer is an example of the first; songbirds or coral reefs might be an example of the second. Another way of formulating such a compromise is that a minimum amount of certain environmental assets should be maintained, based on the idea that these assets are partly complementary to economic assets and partly substitutable by the latter.

3. Utility and Substitution

Economic theory begins with the notion of "economic man" or *Homo economicus*. Economic man enters an exchange market with an ordered set of conscious preferences for goods and services, which is assumed to be fixed and stable over time (Stigler and Becker 1977). How preferences are formed or whether they correspond to biology or physical reality is considered to be outside the scope of economics. There is no explicit notion in the standard utility theory of humans as biological beings whose survival depends on harvesting biological products for food and other purposes. Our direct dependance on agriculture, in turn, results in an indirect dependance on the hydrological cycle, several nutrient cycles (C, N, S, P), the ozone layer for protection against UV radiation and a stable climate and bio-physical environment. It is climatic stability over long time periods that allows humans and other long-lived plants and animals to develop and maintain effective defenses against biological attack by more rapidly evolving micro-organisms.

This neglect of larger context is consistent with, and perhaps accounts for, the general hostility of economic profession to the lexicographic preference ordering which denies universal substitutability. Yet there is much evidence lexico-graphic preference ordering is a better characterization than continuous and differentiable preference functions (Spash and Hanley 1995). The existence of lexicographic preferences casts doubt on the numerous attempts to measure preferences for characteristics of nature such as biodiversity (Gowdy 1997). Stevens *et al* (1991) concluded that when it came to “valuing” wildlife a majority of respondents used decision-making processes inconsistent with the neoclassical assumptions of universal substitution and tradeoffs. Another common assumption is that preferences are fixed. However, there is evidence that preferences are changing and influenced in a coevolutionary way by culture and nature (Norton et al., 1998).

Actually it does matter what we believe. Our preferences, and our actions based on those preferences, have real consequences in the physical universe of which we are a part. Humans may “prefer” to use fossil fuels rather than solar energy, they may “prefer” to trade the Earth’s biological diversity for consumer goods, but acting on these preferences will change the physical world we live in, probably for the worse. Such an outcome would presumably not be preferred.

In fact, preferences in the real world can be inconsistent, as several well-known paradoxes demonstrate. Transitivity is mathematically convenient but it is not necessarily a property of the real world. In reality, most people do not know what they prefer in many situations, because they do not know the whole range of possible choices, still less the consequences of the possible choices. In fact, the consequences may well be unknowable or incalculable. This is certainly the case for many long-term environmental policies.

4. Valuation of “Natural Capital”

In practice, the depreciation of natural capital is quantified only for market-priced extractive resources such as forest products, fish or minerals. Repetto and colleagues at The World Resources Institute have performed detailed studies for a number of countries, including Costa Rica, Indonesia and the Philippines (Repetto and Gillis 1988, Repetto et al. 1989). This approach to estimating depreciation can be extended, in principle, to certain other environmental assets — such as topsoil or recreational land — which provide services with the potential for indirect market valuation e.g. by correlating land prices with climatic and other variables.

However this method breaks down completely when applied to other types of natural capital that do not yield a market product. Examples include climatic stability, the hydrological cycle, the carbon, oxygen and nitrogen cycles, and biodiversity. Since there is no credible basis for assuming that man-made or human capital can substitute for essential ecosystem services such as these, the notion of weak sustainability can only be used as a negative indicator. That is, if the weak sustainability criterion is violated, the system will not survive anyway. Linking to the earlier points on utility, the system inputs are lexicographically ordered.

Attempts to quantify the economic value of these ecosystem services in monetary terms have been undertaken recently (e.g. World Bank 1995, Costanza *et al* 1997). In particular, the latter study concluded that the annual global value of ecosystem services is between $17 trillion and $54 trillion, with a `most likely' value of $33 trillion. Moreover, since most of the value measures were based on the product of marginal prices based on willingness to pay (WTP) times quantity (PQP), whereas the theoretically correct measure would have been consumer surplus (area under the demand curve and above the supply curve), it was argued that the published numbers were in fact underestimates.

At any rate, the PQP for ecosystem services is certainly non-zero. On the basis of cost of protection and amelioration alone, it must be at least a few percent of GWP. On the other hand, the consumer surplus value for some of these services can probably be regarded as *infinite*, for the simple reason that without some of the services in question the biosphere (and human life with it) could not survive. In conventional graphical terms, this means that the demand curve for some ecosystems services becomes vertical before reaching the origin.

Clearly we cannot meaningfully quantify the depreciation of an infinite quantity by using fractional rates. On the other hand, the real depreciation loss is still finite near the margin, at least as long as the biosphere does not collapse. The main point of the exercise would be to estimate the rate of increase of depreciation as the system is perturbed further and further away from its historical co-evolutionary equilibrium state.

Thus, even if the demand curves for essential ecosystem functions could be quantified only in this near-equilibrium region, the current and projected near-term depreciation loss could be estimated quantitatively. This could contribute to making the Pearce-Atkinson criterion far more realistic.

5. Natural Science Perspectives and Sustainability

The practical expression of the strong sustainability concept is likely to be in terms of preservation of certain species (or genera), safe minimum standards for impacts on environmental quality and sustainable use of renewable natural resources. Preservation of the physical magnitude of non-renewable mineral resources would mean leaving them unused. One can interpret this criterion as derived from physical and ecological constraints (carrying capacity) receiving priority over everything else. Clearly, although weak and strong sustainability are usually mentioned in one and the same breath, their formalization differs, since strong sustainability as opposed to weak sustainability does not allow substitution between natural capital and other forms of capital.

Many ecologists would support the idea that environmental sustainability is mainly a matter of stability, resilience and biotic diversity. According to Common and Perrings (1992) *stability* is defined at the level of biological populations. This means that variables return to equilibrium values after perturbation. *Resilience* (resistance to change, or robustness) is defined at the system level and refers to maintenance of organization or structure and functions of an system in the face of stress. Resilience can be considered as a global, structural stability concept, and may cover multiple locally stable equilibria. In other words, stability of a local equilibrium of a system implies resilience of the respective system, but resilience does not necessarily go along with stability of a (each) local equilibrium. Sustainability can thus be directly related to resilience, where stress relates to human influences.

Common and Perrings (1992) refer to this approach as ecological Holling-sustainability (Holling, 1973). The standard neoclassical models do not adequately address fluctuations and cycles. Business cycle theories would seem adequate in this respect, e.g., using Harrod-Domar and multiplier-accelerator models (see Young, 1996). Indeed, we wonder why other types of dynamic macro-economics — apart from growth theory — have seen so little application in environmental economics e.g. to address questions related to the interaction between sustainability and unemployment. Neoclassical models do not incorporate any information about actual ecosystem structure. In order to be able to deal with stability and uncertainty in a way consistent with ecological theory, integration of economic and ecological models is necessary. Integrated models, and especially (co)evolutionary models, seem the obvious tools for dealing with this linkage problem. Unless externalities cover dynamic impacts — including evolutionary effects of activities and decisions made now — "internalization" or "optimization" of such externalities is inadequate to realize environmental sustainability in the sense of Holling. This perspective can be linked to the one of strong sustainability, by recognizing that maintenance of natural capital does require a precautionary approach which takes safety margins into account, as stability is not guaranteed by operating at the margin of optimal levels of capital.

As noted earlier, the operational principles of the Hartwick-Solow sustainability approach were formulated in terms of investment rules. By contrast, in the case of Holling sustainability the operational implications can be formulated along two dimensions. First, "creative destruction" should be allowed. In other words, control for purposes of preservation should not be too tight. Excessively vigorous fire suppression in certain ecosystems might be an example. Second, human influences on remaining natural ecosystems should be reduced to an absolute minimum, without any lower bound. Another difference relates to the sort of (un)sustainability indicators to be used.

The Hartwick-Solow approach implies value based indicators; the Holling approach implies physical and biological indicators.

6. Consistency Between Sciences

The above mentioned perspectives on sustainability are not necessarily always in disagreement with each other. It is possible that they give rise to similar or identical conclusions in some specific cases. The important point, however, is that they may also lead to different and possibly conflicting conclusions, in some situations. When this occurs, one has to make a choice. In view of the fundamental differences of perspectives/starting points this may seem to some be largely a subjective issue, while to others it appears amenable to scientific analysis. We sidestep this question, for the moment.

However, something more can be said. E. O. Wilson (1998) lists several qualities of good theory in general and mathematical models in particular. Among these is "consilience", that is: "Units and processes of a discipline that conform with solidly verified knowledge in other disciplines have proven consistently superior in theory and practice to units and processes that do not conform." The economic notion of weak sustainability does not pass the test of consilience with the established laws of biological and physical science. Weak sustainability cannot be reconciled with accepted knowledge from other sciences, with respect to the following points:

1. The economic characterization of preferences emphasizing substitution between consumed goods and services is inconsistent with accepted findings and principles from psychology, biology, and is at odds with empirical results from environmental economics, in particular in economic valuation studies. Lexicographic preferences are realistic, notably in the context of trading-off economic and environmental services. However, they receive no serious attention, in spite of the fact that they imply a different economic perspective on sustainability.

2. The foundation of weak sustainability developed in growth theory (by Hartwick (1977) and Solow (1986) was formulated explicitly for non-renewable resources, not for complex biological systems. In ecological systems sustainability is present in systems which are resilient to perturbations. Static aggregate growth models of optimal allocation are inconsistent with scientific findings describing living evolutionary systems.

3. Production functions in the standard analysis of economic growth and environmental sustainability assume unlimited substitution options in physical terms. In many cases the results can not really be interpreted, due to the fact that there is no clear relationship between physical and value units — for process inputs and outputs. A recent discussion on this issue is presented in a special issue of the journal "Ecological Economics" (1998). For an evaluation see van den Bergh (1998).

However, for the present we pass on the most interesting question, which might be recast as "under what specific conditions/circumstances could the Hartwick-Solow criteria be accepted — if any?" . In more familiar language, for what questions is weak sustainability, test adequate, and conversely, for what questions must we adopt a stricter test?

7. Conclusions

Actually, both "weak" and "strong" criteria, as formulated above, involve an implicit assumption that we would like to draw attention to, and challenge. They both imply a centralized decision-making process and a decision-making process and a decision-maker who decides on behalf of "society" among alternative programs and plans. But the real world is not at all like that. In reality, virtually all economic decisions are decentralized among many much narrower interests, namely individuals, family groups, or firms. Even with the best intentions as regards future generations and planetary welfare, most decision-makers will optimize within a much narrower context.

Moreover, it is quite clear that whereas a collection of neo-classical ‘homo-economics whith perfect information exchanging material goods in a perfectly competitive market might achieve a Pareto-optimum allocation, the environmental consequences could still be devastating. On the other hand, if firms were to sell “services”, rather than “products”, and all material goods were regarded by producers as “capital” rather than “throughput”, the incentives facing decentralized managers would be much more consistent with planetary sustainability. Decentralized decision-makers at the family or firm level would not, and need not, choose between “weak” or “strong”.

Much of the confusion in the discussion of strong sustainability arises from a failure to distinguish between the two assumptions dividing weak and strong sustainability. The first is the assumption of substitutability between natural and manufactured capital. The second is that economic well-being “covers” all other concerns. If the second assumption is accepted (as it sometimes is by advocates of strong sustainability) then the argument about substitutability boils down to a purely economic debate about elasticities of substitution, technological advance and so on. If, on the other hand, substituting financial capital for natural resources is incompatible with maintaining a suitable physical environment for the human species, then strong sustainability implies that we must step outside the conventional market framework in order to establish the conditions for maintaining human happiness.

Bromley (1998, p238) suggests to move away from “sustainability” to “social bequests”: “This approach liberates us from a zero-sum game in which our gain is an automatic loss for future generations. Regard for the future through social bequests shifts the analytical problem to a discussion about deciding what, rather than how much, to leave for those who will follow.” If we cast the problem as “how much” this always implies that some amount of a resource should be used and some left. We use 25% of a rainforest and leave the rest, for example. But then the next time we make a decision we start all over again and use 25% of what’s left, and so on, until it is all gone. By focusing on bequests of specific rights and opportunities for future generations, we can get away from the straightjacket of substitution and marginal tradeoffs of neoclassical theory.

Also, whereas global sustainability and sustainable development have received an enormous amount of attention, their implications for open systems like regions and countries have not been dealt with systematically. The large and growing literature on international trade and environment adopts essentially a static perspective, focusing mainly on externalities. Regional or national sustainability should clearly be consistent with global sustainability. Their analysis requires an integration of insights in growth theory, international trade theory, resource economic, and ecology. No one has yet succeeded to do this, and it seems likely that analytical approaches will fall short in this respect.

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