Ecological Economics, 8 (1993) 269–288
Elsevier Science Publishers B.V., Amsterdam

'Limits to growth' and 'sustainable development': grappling with ecological realities

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(Received 6 January 1992; accepted 11 December 1992)

ABSTRACT

Ekins, P., 1993. 'Limits to growth' and 'sustainable development': grappling with ecological realities. *Ecol. Econ.*, 8: 269–288.

The paper has three main sections. The first discusses the 'limits to growth' debate of the 1970s, identifying concern with three potential kinds of limits: ecological limits to the physical scale of economic activity, limits to the economic welfare to be derived from growth of economic activity, and social limits to economic growth. The second section explores the same issues through the sustainable development literature of the late 1980s and the 1990s to date. The principal change over the 20 years concerned, a period also framed by the Stockholm Environment Conference and UNCED, is far greater acceptance of the existence of threatening environmental damage and the need for active policy to address it. No consensus has yet emerged, however, on the relationship between economic growth and welfare or ecological or social sustainability. The third section indicates the scale of the task if global economic growth is to be reconciled with ecological sustainability, and advocates a strategy for sustainability that principally involves differentiating between North and South and forging new economic relations between them.

1. INTRODUCTION

Following on from the 1992 Earth Summit, the UN Conference on Environment and Development (UNCED) in Brazil, it is perhaps worth reflecting on what is perhaps the major change in approach over the 20 years since the 1972 UN Conference on the Environment in Stockholm. Today the key phrase is 'sustainable development'. Then it was 'limits to growth'. The purpose of this paper is to examine and relate these two concepts; to see whether they are compatible and on what terms, and to judge which provides a more realistic approach to the environmental economic problems of the present time.

2. THE ECONOMIC GROWTH DEBATE

In order to shed light on the arguments for and against 'limits to growth' that raged so heatedly in the 1970s, not just among economists but in society at large, it is necessary to unpack the concept, in particular by asking 'what sort of limits?' and 'limits to what kind of growth?' At the outset it should be observed that the limits in question can be either ecological or social; while the growth in question can be that of the throughput of physical resources, GNP or welfare.

The term 'limits to growth' itself was the title of a book by Donella and Dennis Meadows and a team from the Massachusetts Institute of Technology (MIT), which was the principal fuel for the subsequent debate. For the Meadows team the limits were ecological limits, and they applied to economic growth, understood as growth in production as measured by GNP, which they assumed implied a similar increase in the consumption of resources. They concluded that (Meadows et al., 1972, p. 23):

> The most probable result (of reaching the limits to growth) will be a rather sudden and uncontrollable decline in both population and industrial capacity.

The Meadows' model assumed that population and industrial capital would grow exponentially, leading to a similar growth in demand for food and non-renewables and in pollution. The supply of food and non-renewable resources were, however, taken to be absolutely finite. Not surprisingly, exponential growth within finite limits resulted in systematic breakdown; the expansive nature of compound growth also meant that the finite limits could be raised by a factor of four without significantly affecting the results.

While the 'limits to growth' thesis struck a chord with the general public, economists and other scientists were quick to seek to discredit it. One of the most comprehensive rebuttals came from a team at Sussex University's Science Policy Research Unit (Cole et al., 1973). They criticised the relationships in Meadows' model, the assumptions on which the model was based and the emphasis on purely physical parameters.

On the basis of their critique, Cole et al. re-ran Meadows' model with different assumptions and produced quite different results. This was also not a priori surprising because the key assumption they replaced was that of absolute limits by introducing ongoing exponential increases in available resources (through discovery and recycling) and the ability to control pollution. "To postpone collapse indefinitely these rates of improvement must obviously be competitive with growth rates of population and consumption so that even if the overall growth is rapid, it is also 'balanced'. In this case some kind of stable but dynamic equilibrium is obtained" (Cole et al., 1973, p. 119). The authors also claimed that, at 1% and 2%, the actual

numerical values used as improvement rates for the various technologies were compatible with historical experience.

Lecomber (1975) admirably expresses the difference between resource optimists, such as Cole et al., and pessimists such as the Meadows' team. He identifies the three key effects that can reduce depletion or pollution: changes in composition of output, substitution between factor inputs, and technical progress (more efficient use of the same input). If these three effects add up to a shift away from the limiting resource or pollutant equal to or greater than the rate of growth, then the limits to growth are put back indefinitely. But, Lecomber (1975, p. 42) warns: "[This] establishes the *logical* conceivability, not the certainty, probability or even the possibility in practice, of growth continuing indefinitely. Everything hinges on the rate of technical progress and possibilities of substitution. This is perhaps the main issue that separates resource optimists and resource pessimists. The optimist believes in the power of human inventiveness to solve whatever problems are thrown in its way, as apparently it has done in the past. The pessimist questions the success of these past technological solutions and fears that future problems may be more intractable." Lecomber looks for evidence in an effort to judge between these two positions, but without success. "The central feature of technical advance is indeed its uncertainty" (Lecomber, 1975, p. 45). This conclusion is of relevance to the contemporary situation with sustainable development, as will be seen.

Many of the same points as those of Cole et al. (1973) are made, and the same beliefs about the efficiency of future technical change are held, by Wilfred Beckerman (1974) in his defense of economic growth. However, Beckerman also introduces several other arguments not related to technology. Firstly Beckerman (1974, pp. 18, 20) stresses: "It is essential not to confuse the issue of how consumption should be spread over time, which is the growth issue, with that of how resources should be used at any moment of time. The fact that resources are misallocated at any moment of time on account of failure to correct for externalities does not necessarily mean that the growth rate is wrong." Beckerman's point is that insofar as environmental degradation is caused by externalities, or 'spillover effects', which are failures of resource allocation, they cannot be solved by tinkering with rates of economic growth. This is true as far as it goes, but misses the important point that if these externalities persist to any given extent, their absolute effect in a large economy will be greater than in a small one. Given that failures to remedy externalities are common, due not least to the power of the vested interests that are causing them, opposition to the economic growth that amplifies them would seem a not irrational position on the part of those adversely affected.

The other point about rectifying resource misallocations is that per se it

may reduce GNP growth. Lecomber (1975, p. 59) says: "It is misleading to regard environmental policies of this sort as *alternatives* to reducing economic growth since this would be their incidental effect. Benefits which are not included in GNP would be traded for other (smaller) benefits which are. GNP would fall and, during the period of transition to such policies, growth would fall, probably substantially." Of course, there is no certainty that correcting resource misallocations reduces growth, but if they could be corrected at zero net cost, which is what no reduction in growth implies, then there was no economic rationale for them in the first place. While such singular misallocations may exist, it is highly unlikely that the enormous externalities reflected in current environmental degradation are of this sort.

Whatever the potential of technological change, there are certain physical constraints, defined by the laws of thermodynamics, that cannot be circumvented. The Second Law — that all activity and transformation of energy or materials leads to an increase of entropy — has been most extensively related to economics by Georgescu-Roegen (1971).

In this analysis it is the increase of entropy that is the ultimate limit to growth. Economic activity increases entropy by depleting resources and producing wastes. Entropy on earth can only be decreased by importing low entropy resources (solar energy) from outside it. This energy can renew resources and neutralise and recycle wastes. To the extent that the human economy is powered by solar energy, it is limited only by the flow of that energy. Growth in physical production and throughput that is not based on solar energy must increase entropy and make environmental problems worse, implying an eventual limit to such growth. Growth in physical production based on solar energy is limited by the quantity and concentration of that energy. GNP can free itself from these limits only to the extent that it 'decouples' itself from growth in physical production; what Daly (1977, p. 118) calls "Angelized GNP". As will be seen later, such decoupling has occurred to some extent, but the entropy law decrees that it can never be complete. As Daly (1977, p. 119) puts it: "It would be necessary for us to become angels in order to subsist on angelized GNP."

Another Beckerman position concerns the overall benefit of economic growth, still understood as growth in GNP: "A failure to maintain economic growth means continued poverty, deprivation, disease, squalor, degradation and slavery to soul-degrading toil for countless millions of the world's population" (Beckerman, 1974, p. 9) and "This book is chiefly about why economic growth is still an important source of increased welfare and why it can safely be pursued without fear of environmental catastrophe" (Beckerman, 1974, p. 35). In believing that GNP is designed to measure "changes in economic welfare" (rather than production or

income), Beckerman differs from some economists, but he concedes that it may not be a very good measure of such changes (Beckerman, 1974, p. 77). However, he considers that there are significant positive as well as negative omissions from GNP and cites Nordhaus and Tobin's (1971) figures as showing that: "The absolute rise in the 'good' items that are normally excluded from GNP has exceeded the absolute rise in the 'bad' items (both those that are included and those that are excluded from GNP)" (Beckerman, 1974, p. 86).

Beckerman's argument is therefore twofold: poor countries need economic growth to pull them out of poverty; rich countries pursue economic growth because of the net benefits it brings. With regard to the first of these arguments, there is now some doubt, rather more than when Beckerman was writing, whether economic growth per se is what poor people in poor countries need to improve their life prospects. Using the terminology introduced by Sen (1983, p. 754), entitlements such as ensured access to resources and capabilities to use those resources, neither of which are the automatic results of economic growth, may be even more important. Where these lead to more secure but non-market subsistence, they will not even show up as economic growth.

With regard to the second argument, it is a view which is diametrically opposed to the views of E.J. Mishan. In the works so far surveyed the emphasis has been on the feasibility or otherwise of economic growth. Its desirability has either been a moot point or, as with Beckerman, strongly asserted. It was the institutionalist economist K.W. Kapp who made the first thorough-going exploration of the social costs of the growth process (Kapp, 1950), but it was E.J. Mishan (1967, 1977) who first brought these costs to widespread public notice. Mishan (1977, p. 10) identified them thus:

> "The uglification of once handsome cities the world over continues unabated. Noise levels and gas levels are still rising and, despite the erection of concrete freeways over city centres, unending processions of motorised traffic lurch through its main thoroughfares. Areas of outstanding natural beauty are still being sacrificed to the tourist trade and traditional communities to the exigencies of 'development'. Pollution of air, soil and oceans spreads over the globe... The upward movement in the indicators of social disintegration — divorce, suicide, delinquency, petty theft, drug taking, sexual deviance, crime and violence — has never faltered over the last two decades."

It is Mishan's thesis that these and other ill effects are the results of economic growth and far outweigh its benefits. Mishan sees the pursuit of such growth as leading Western civilisation to its nemesis. As long as these effects remain important, as they undoubtedly still do, Mishan's thesis stands unfalsified. Whether he will be proved right is, of course, a different matter.

The ecologists' concern was with the physical limits to economic growth. Mishan's focus is on the limits to social welfare that can be derived from growth. Hirsch (1976, p. 4) adds to the picture by postulating social limits to growth, distancing himself from the ecologists' critique with the words: "The concern with the limits to growth that has been voiced by and through the Club of Rome (Meadows et al., 1972) is strikingly misplaced. It focuses on distant and uncertain physical limits and overlooks the immediate if less apocalyptic presence of social limits to growth."

Hirsch's social limits derive from two causes: the increasing importance of positional goods; and the breakdown of individual morality in an affluent, growing economy. The positional economy "relates to all aspects of goods, services, work positions, and other social relationships that are either (1) scarce in some absolute or socially imposed sense or (2) subject to congestion or crowding through more extensive use" (Hirsch, 1976, p. 27). As incomes rise, the demand for positional goods increases; with fixed or very inelastic supply, the goods are either rationed through price (e.g., desirable resort properties) or criteria of eligibility (e.g., more stringent examinations) or their quality is degraded through overcrowding (e.g., roads). The effect is either to reduce growth, or the welfare to be derived from it or both.

On the subject of morality, Hirsch (1976, p. 141) writes: "The point is that conventional, mutual standards of honesty and trust are public goods that are necessary inputs for much of economic output.... Truth, trust acceptance, restraint, obligation, these are among the social virtues which are also now seen to play a central role in the functioning of an individualistic contractual economy." Yet, Hirsch (1976, p. 175) asserts, these are precisely the virtues that are undermined by the selfsame individualism. "Economic growth undermines its social foundations."

Daly (1977, pp. 170, 176) brings the argument full circle by indicting "growthmania" for errors in both the ecological and moral spheres: "Economics has overlooked ecological and moral facts of life that have now come home to haunt us in the form of increasing ecological scarcity and increasing existential scarcity.... Ultimate means have been treated as if they were limitless, and the Ultimate End as if it were unreal."

Daly's solution to growthmania is the Steady-State Economy, "an economy with constant stocks of people and artifacts, maintained at some desired, sufficient levels by low rates of maintenance 'throughput'" (Daly, 1977, p. 17). The throughput is limited by strict quotas, auctioned by the government, on depletion of resources. The population is limited by the equal per capita issue of transferable birth licences. And inequality of income and wealth is limited by the setting of maximum and minimum levels, with redistribution from rich to poor. The dual ecological and social

components of Daly's steady-state are explicit in the subtitle to his book: 'The Economics of Biophysical Equilibrium and Moral Growth'.

3. FROM LIMITS TO GROWTH TO SUSTAINABLE DEVELOPMENT

The 1970s' limits to growth critiques, both physical and social, failed to dent the social consensus in favour of economic growth, so that by the time the Brundtland Commission produced its report, *Our Common Future* (WCED, 1987), on environment and development, the emphasis was placed on a perceived complementarity between growth and environment. In her introduction to the report, Mrs. Brundtland calls for "a new era of economic growth — growth that is forceful and at the same time socially and environmentally sustainable" (WCED, 1987, p. xii).

This bullish attitude was justified by statistics which showed that over the period 1972–1986 the relationship between energy use and economic growth in industrial countries had undergone a significant change from the broadly proportional relation that had pertained before. In the US, energy intensity (the amount of energy used per unit of GDP) from 1973–1986 diminished by 25%. Over the OECD as a whole, it fell by 20% from 1973–85. In the same period for countries belonging to the International Energy Agency, GDP grew by nearly 32%, but energy use only by 5% (WRI, 1990, p. 146). A 'decoupling' of economic growth from energy consumption was proclaimed.

A major difference in the environmental debate since the publication of the Brundtland Report has been the positive engagement of business, which in the 1970s was still broadly unconvinced that there was a problem. Two significant international business initiatives have been launched, the 'Business Charter for Sustainable Development' for the International Chamber of Commerce (ICC) and the Business Council for Sustainable Development (BCSD), formed to give advice from a business perspective to the 1992 UN Conference on Environment and Development.

Both these initiatives believe environmental sustainability to be compatible with growth: "Economic growth provides the conditions in which protection of the environment can best be achieved, and environmental protection, in balance with other human goals, is necessary to achieve growth that is sustainable" (ICC, 1990). The BCSD view on the compatibility of growth and environmental protection is somewhat more ambivalent, as expressed in its report to UNCED in May 1992. In this report the relationship of compatibility is in one place characterised as extremely problematic, thus: "The requirement for clean, equitable economic growth remains the biggest single difficulty with the larger challenge of sustainable development. Proving that such growth is possible is certainly the greatest

task for business and industry" (Schmidheiny, 1992, p. 9). Elsewhere the relationship (with trade thrown in) is characterised not just as compatibility but as complementarity: "Taking a long-term perspective, it follows then that economic growth, trade expansion and environmental protection are goals that can only be reached in conjunction" (Schmidheiny, 1992, p. 70).

In a new and even more optimistic twist to this debate, Bernstam (1991) postulates that industrialisation under free market conditions exhibits a characteristic relationship between growth and the environment: in the early days there is a negative trade-off at the expense of the environment. This effect diminishes as industrialisation proceeds and, at a certain historical moment, there is a positive relationship between the two. At this point "economic growth can reduce pollution if it increases the productivity of resources (that is, reduces wastes) faster than both resource output and population growth" (Bernstam, 1991, pp. 33, 34).

Bernstam (1991, p. 40) asserts that in industrial market economies this condition is now being met by the operation of what he calls the "Invisible Environmental Hand". I have subjected this assertion to detailed criticism elsewhere (Ekins, 1992), but the most important point is that it remains at the level of pure conjecture. In fact, it is flatly contradicted by trends in energy use since 1986. US energy intensity actually increased (that is, more energy was used per unit of GDP) in 1987 and 1988, as did that of several European countries (WRI, 1990, p. 146). Despite some limited evidence on air pollution (World Bank, 1992), there is no evidence that, over a prolonged period, Bernstam's condition for growth to reduce overall environmental impacts is being met.

Beckerman (1992), arguing for economic growth in developing countries, adopts the same line of argument as Bernstam (1991) with an intriguing difference. Bernstam's thesis was that continuing economic growth in industrial countries would reduce their contribution to global pollution, which would go some way towards compensating for the inevitable rise in pollution from growth in developing countries. Beckerman contends that it is *developing countries* that need economic growth to improve their environments, at least in important areas such as access to drinking water, sanitation and air quality. He concludes: "In the longer run, the surest way to improve your environment is to become rich" (Beckerman, 1992, p. 491). Beckerman is roundly dismissive of the whole debate around sustainability: "The aggregative concept of global sustainability... seems to be either morally indefensible or devoid of operational value", while the question "how do we achieve sustainable development?" is "unanswerable and meaningless" (Beckerman, 1992, pp. 491–492).

Beckerman's is not the only important voice from the 1970s debate to have restated their essential conclusions in the 1990s. A new report from

Meadows et al. (1992, p. 12) states: "[The possible paths into the future] do not include continuous growth. The choices are to bring the burden of human activities upon the earth down to a sustainable level through human choice, human technology and human organisation, or to let nature force the reduction through lack of food, energy or materials, or an increasingly unsound environment".

The emphasis on continuing limits to growth is also echoed in a publication which includes contributions by two Nobel laureates in economics, one of whom writes: "Saving the environment will certainly check production growth and probably lead to lower levels of national income. This outcome can hardly surprise. Many have known for a long time that population growth and rising production and consumption cannot be sustained forever in a finite world" (Tinbergen and Hueting, 1991, p. 38).

It will be noticed that, while the resource pessimists' conclusions are essentially unchanged, and with the exception of the Bernstam/Beckerman views, there has been a significant shift in the resource optimists' position since the 1970s. Then, environmental limits were perceived to be either non-existent or automatically self-delimiting. Now the consensus among the mainstream optimists, as expressed in the Brundtland, WRI or BSCD reports, is that environmental problems are real and threatening and that to be reconciled with continuing economic expansion *active policy* on the part of both business and government will be required.

This consensus position received one of its most sophisticated restatements in the *World Development Report 1992* (World Bank, 1992). This report accepts the gravity of the environmental situation. Further, it accepts that some environmental problems are "exacerbated by the *growth* of economic activity" (p. 7, original emphasis). Exploring the implications of a 3.5-times rise in world output by 2030, it acknowledges that "If environmental pollution and degradation were to rise in step with such a rise in output, the result would be appalling environmental pollution and damage" (p. 9).

The Report recommends a twin strategy to achieve both growth and environmental conservation. Most importantly, "Some problems are associated with the *lack* of economic development; inadequate sanitation and clean water, indoor air pollution from biomass burning, and many types of land degradation in developing countries have poverty as their root cause. Here the challenge is to accelerate equitable income growth..." (p. 7, original emphasis). The Report accepts that "these 'win–win' policies will not be enough" (p. 5) and that, in other cases, "there may be trade-offs between income growth and environmental protection" (p. 1). However, "The evidence indicates that the gains from protecting the environment are often high, and that the costs in foregone income are modest if appropriate

policies are adopted" (p. 1). The gains from 'win–win' opportunities on the one hand, and only modest costs on the other, could, on this analysis, result in both the 3.5-times rise in world output and "better environmental protection, cleaner air and water, and the virtual elimination of acute poverty" (p. 2).

The greater acceptance of environmental threat by policy-makers and academics than in the 1970s has also led to an explosion in research activity focused on the concept of 'sustainable development' that has been popularised by the Brundtland Report. By 1989 the literature had generated "a gallery of definitions" (Pearce et al., 1989, pp. 173–185). Such diversity of meaning clearly militates against clarity of discourse, to the extent that one survey of the sustainable development scene was led to conclude (Lele, 1991, p. 613):

> "[Sustainable development] is a 'metafix' that will unite everybody from the profit-minded industrialist and risk-minimising subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximising policy-maker, the goal-oriented bureaucrat and, therefore, the vote-counting politician."

Not surprisingly perhaps, Lele (1991, p. 613) finds that this all-inclusive formulation "suffers from significant weaknesses in:

(a) its characterisation of the problems of poverty and environmental degradation;
(b) its conceptualisation of the objectives of development, sustainability and participation; and
(c) the strategy it has adopted in the face of incomplete knowledge and uncertainty."

Notwithstanding these weaknesses, it is possible to identify several strands in recent writing about the economy and the environment, which do shed further light on the growth/environment relation. These strands can be identified as an increasing awareness of the extent of environmental externalities and a consequent stress on the need for environmental evaluation; a new perception of the differences, and therefore of the need to distinguish, between natural and man-made capital; an emphasis on John Hicks' original definition of income as production remaining net of capital depreciation, i.e., income is *defined* as a sustainable quantity; and a concern to reflect these issues and effects in quantitative economic analysis and especially to incorporate them in the System of National Accounts.

Each of these subjects now has a substantial literature, which can be no more than hinted at here. The extent of externalities in a modern industrial economy was explored by Leipert (1989) in his study for West Germany of the 'defensive expenditures' to which they give rise. Leipert classified these expenditures in six areas — the environment, transport, housing, security,

health and work — and found that they had increased from an equivalent of 5% to an equivalent of 10% of West German GNP between 1970 and 1985, even ignoring global effects such as ozone depletion and climate change, and the environmental impacts of West German production and consumption on other countries.

The measurement of environmental damages is discussed in Pearce and Turner (1990, pp. 120–158) where they seek to make operational the concept of total economic value as actual use value plus option value plus existence value. There is still considerable controversy surrounding the reliability and appropriateness in many environmental contexts of the principal method discussed, contingent valuation (Hueting, 1989; Common and Blamey, 1992).

The relationship between natural and man-made capital is explored in Pearce et al. (1989, pp. 34 ff.) and Pearce and Turner (1990, pp. 43 ff.). Taking sustainability to mean a non-declining capital stock, this can be taken to refer to total capital stock or to man-made and natural capital stocks separately (the 'weak' and 'strong' sustainability condition, respectively). Which of these conditions is appropriate depends on the degree of substitutability of the two kinds of capital, which itself depends on issues of uncertainty, irreversibility and uniqueness. Daly (1991) argues that, in fact, "natural capital (natural resources) and man-made capital are complements rather than substitutes" (p. 20).

The essential sustainability of the Hicksian concept of income was stressed in several papers in Ahmad et al. (1989) and clearly demands that, in calculations of income, depreciation of natural capital should be deducted from gross production. That this is not done in the case of National Income has attracted increasing concern, with many writers advocating reform to the System of National Accounts. Ahmad, et al. (1989) contains several suggested approaches as to how this might be achieved.

Notwithstanding the theoretical and (rather less) practical progress that has been made on these issues, it is true to say that it has not been able to create a consensus over the relationship between environmental sustainability and economic growth. As Costanza has written: "The bottom line is that there is still enormous uncertainty about the impacts of energy and resource constraints... Ultimately, no one knows. Both sides argue as if they were certain, but the most insidious form of certainty is misplaced ignorance" (Costanza, 1989, p. 3). This sentiment is echoed by Pearce and Turner (1990) who, reviewing the 'limits to growth' issue, write: "Our belief is that only by improving substantially our understanding of economy–environment interactions will we get a better grasp of these wider issues" (p. 28).

Modesty in the face of uncertainty is, doubtless, laudable but it can all too easily lead to inaction or mere calls for more research. It is possible that UNCED's very modest achievements may lead to just that. Maurice Strong, UNCED's Secretary-General who also organised the 1972 Stockholm Environment Conference, summed up the post-UNCED danger in the words: "We don't have another twenty years now. I believe we are on the road to tragedy" (reported in Meadows, 1992). What, then, might be a prudent course of action with regard to economic growth and the environment, in the face of radical uncertainty?

4. ACHIEVING SUSTAINABILITY

At its simplest, the sustainability of something is its capacity for continuance into the future. Where economic activity or, more generally, a way of human life, is concerned, this sustainability will depend on economic, social (including cultural and ethical), and ecological factors. These factors are themselves interdependent, so, for example, ecological sustainability (the absence of ecological constraints on the capacity for continuance) will be influenced by social arrangements (Lele, 1991, pp. 609–610; Pezzey, 1992). The interdependence of these factors, and their change over time, is captured by Norgaard's concept of 'co-evolution' (Norgaard, 1992).

As we have seen, there is now widespread agreement, which formed the basis of UNCED, that most current economic development is not ecologically sustainable and that the unchecked consequences of this are likely to be unpleasant and perhaps catastrophic. The core of continuing disagreement lies in the extent to which new technologies can resolve problems of ecological unsustainability, while permitting continuing growth of GNP. The disagreement derives from differing positions of technological optimism and pessimism.

It is now clear that this issue will not be resolved theoretically. It is essentially an empirical question. But there is no reason for the lack of a priori theoretical agreement on this point to impede practical implementation of a policy which all sides agree to be desirable on both ecological and economic grounds; namely, the internalisation of environmental externalities and/or their reduction through the determined introduction of technologies to reduce environmental impacts. If the optimists are proved right, so much the better; if the pessimists are nearer the mark, at least environmental calamity will have been averted.

Achieving this technological transformation, however, and being able to respond further should it prove insufficient to adequately reduce environmental damage, depends in my view on two radical shifts in orientation: the adoption of ecological sustainability as the principal economic objective in

place of economic growth, and the development of a new accounting system to reflect the ecological contributions to and impacts of economic activity, and to clarify the relationship of production growth to economic welfare.

Shifting the policy emphasis from growth to sustainability

I have argued in detail elsewhere on the need for a shift in policy emphasis from growth to sustainability if environmental problems are to be adequately addressed (Ekins, 1989). Maintaining the current orientation towards growth, with all its concomitant pressures towards business as usual, is much less likely to introduce the changes for ecological sustainability that are necessary.

An equation used by Paul and Anne Ehrlich (1990, p. 58) indicates the scale of the technological challenge if both sustainability and GNP growth are to be achieved. The equation relates environmental impact (I) to the product of three variables: population (P), consumption per capita (C), and the environmental intensity of consumption (the environmental damage per unit of GDP, T). This last variable captures all the changes in technology, factor inputs, and the composition of GNP. Thus:

$$I = PCT$$

In accordance with the widespread agreement at UNCED, it is assumed that current levels of I are unsustainable. With regard to energy consumption and climate change, the Intergovernmental Panel on Climate Change (IPCC) calculates that carbon dioxide emissions will quickly have to fall by a minimum of 60% to halt global warming. Three other greenhouse gases — N_2O, CFC-11, CFC-12 — also need cuts of more than 70% (Houghton et al., 1990, p. xviii). With regard to other environmental problems, the Dutch National Environmental Policy Plan (MOHPPE, 1988) argues for cuts in emissions of 80–90% for SO_2, NO_x, NH_3 and waste-dumping, 80% for hydrocarbons and 100% for CFCs. Thus with regard to I overall, it seems conservative to suggest that sustainability demands that it should fall by at least 50%. With regard to population, the UN's recent projections indicate a global figure of 10 billion by about 2050 (Sadik, 1991, p. 3), about twice today's level. With regard to consumption, what is considered a moderate economic growth rate of 2–3% results in a quadrupling of output over 50 years. Thus, where subscript 1 indicates the quantity now and the subscript 2 indicates the quantity in 50 years time, we have:

$$I_2 = 1/2 \times I_1 \quad \text{(for sustainability)}$$

$$\left.\begin{aligned} P_2 &= 2P_1 \\ C_2 &= 4C_1 \end{aligned}\right\} \quad \text{(by assumption)}$$

For the Ehrlich equation to hold, this means that $T_2 = 1/16\ T_1$. In other words the environmental impact of each unit of consumption would need to fall by 93% over the next 50 years to meet the rather conservative condition for sustainability that has been adopted. Moreover, in order not to check GNP growth, the technological innovation involved would have to be non-inflationary. Tinbergen and Hueting (1991, p. 37) are openly sceptical of the possiblity of this: "Saving the environment without causing a rise in prices and subsequent check of production growth is only possible if a technology is invented that is sufficiently clean, reduces the use of space sufficiently, leaves the soil intact, does not deplete energy and resources... *and* is cheaper (or at least not more expensive) than current technology. This is hardly imaginable for our whole range of current activities." One does not have to be a technological pessimist to share their doubts.

The extent to which growth itself undercuts improvements in environmental technology is illustrated by the Fraunhofer Institute's study on the macroeconomic effects on the (West) German economy of measures to prevent global warming, preliminarily reported in Schoen (1992). While technical measures were estimated to be able to cut CO_2 emissions from industry by 81.2 million tons per annum from 1987 levels by the year 2005, increased production over that period (taking into account intersectoral changes in favor of less energy-intensive sectors) resulted in more CO_2 emissions of 64 million tons p.a. Thus only 17.2 million tons p.a., or 21% of the technical potential, actually shows up as reduced emissions. The rest simply goes to counteract the increased emissions due to production growth (Schoen, 1992, p. 7).

Elsewhere (Ekins, 1991a), I have performed another calculation on the basis of the Ehrlich equation using different assumptions and the following figures in World Bank (1990, table 1, pp. 178–179):

1988 GNP/Capita (C) in High-Income Countries = \$17 080
1988 Population (P) in High-Income Countries = 784.2 million (m)
1988 GNP/Capita in Low- and Middle-Income Countries = \$750
1988 Population in Low- and Middle-Income countries = 3 952m

The different assumptions for 50 years on were: that I must still be halved; that P will double, with all the increase in the Third World; that C will quadruple in the Third World (low- and middle-income countries), but stay constant in high-income countries. These assumptions yield the following figures for the year 2038 (1988 + 50):

2038 GNP/Capita (C) in High-Income Countries = \$17 080
2038 Population (P) in High-Income Countries = 784.2m

2038 $C \times P$ in High-Income Countries = \$13.4 tr (all as before)
2038 World Population (P_2) = $2P_1$ = 9 472m
2038 Population in Low- and Middle-Income countries = 8 688m
2038 GNP/Capita in Low- and Middle-Income Countries = \$3 000
2038 $C \times P$ in Low- and Middle-Income Countries = \$26.06 tr

With $P_2 = 2P_1$, $I_2 = 1/2\ I_1$ (by assumption), it is easily verified from the Ehrlich equation that $T_2 = 0.21\ T_1$. This means that T in this case would need to fall by 79%.

The difference between the two figures with and without Northern income growth (93% and 79%) is further evidence of the enormously skewed nature of current consumption patterns. With *no* increase in consumption anywhere in the world, but with other assumptions unchanged, the Ehrlich equation indicates a necessary cut in environmental intensity of 75%. Allowing the Third World, with three quarters of the world's population, to more than double its population and quadruple its consumption per head (when its average level becomes still only about 20% of that in the First World) only raises the figure to 79%. But quadrupling the much larger consumption of First World countries as well raises it to 93%.

Such considerations suggest that the best and perhaps the only strategy for achieving ecological sustainability involves differentiating between North and South. In the South, very considerable percentage increases in current very low per capita income levels would appear to be compatible with environmental sustainability, even allowing for forecast population growth, provided that this is accomplished using the most environmentally advanced technologies, although the problems of transferring the technologies between different economic and cultural milieux should not be underestimated. There should also be a determined programme of ecological regeneration in the South through afforestation, soil conservation and small-scale irrigation, which could increase production there and simultaneously increase the natural resource base.

In the North the sustainability problem is quite different. High levels of per capita income mean that relatively small percentage growth rates result in large absolute increases in consumption and, therefore, in associated environmental impacts. That production growth in the North does not necessarily alleviate poverty there is shown by the evidence of the 1980s, which indicates that the number of people below the poverty line in some countries (e.g., the US and UK) increased despite growth in GDP (UNDP, 1991, pp. 30–31). Further, Goodland and Daly (1992) from the World Bank give ten reasons why growth in the North is also not the solution to poverty in the South. This decoupling of Northern growth from poverty alleviation,

and the fact that such growth greatly increases the demands on environmental technologies in the resolution of environmental problems, strengthens the argument for a wholesale shift of objectives in the North from growth to sustainability, through the radical ecological transformation of production and consumption. Any production growth that may still result would have to be compensated for by even greater falls in environmental intensity.

A further condition for sustainable development in North and South is a restructuring of the economic relations between them; a complex issue I have discussed in Ekins (1991b), but which can be no more than mentioned here.

Providing more rigorous indicators of welfare and production

Economic growth and growth in GNP are usually taken taken to be synonymous. Thence the positive link with social welfare is also normally taken for granted. As we have seen, a key theme in the limits to growth debate has been a rejection of this positive link between growth and welfare. A more recent development has been a challenge of the identification of economic growth with growth in GNP, and a determined effort to reform GNP to take account of environmental impacts.

Hueting (1986; Hueting and Leipert, 1990) has consistently denied that economic growth means growth in GNP. His argument is that the purpose of the economy, and therefore the proper subject of economics, is the promotion, not of production and consumption, but of *welfare* (to which, of course, production and consumption may contribute). Logically, therefore, economic growth should mean an increase in welfare, which could have a variety of components of which Hueting (1986, pp. 243–244) identifies seven: production, environment, employment, leisure, working conditions, income distribution, and safety of the future. GNP growth at best is an indicator of production growth (but see below); economic growth should mean that welfare has increased, implying ideally that the contributions of all the above have been taken into account.

It is to make operational such a broader notion of economic growth that various different indicator systems have recently been proposed, including the Human Development Index (UNDP, 1990, 1991, 1992), Daly and Cobb's (1989) Index of Sustainable Economic Welfare and Victor Anderson's (1991) Global Report indicators. For further discussion of these issues and the elaboration of a four-component indicator framework, see Ekins (1990) and Ekins and Max-Neef (1992).

If the link between GNP growth and welfare is problematic, GNP's status even as an indicator of economic production is increasingly being

called into question. GNP is supposed, of course, to measure, as a triple identity, production, expenditure and income. One problem already mentioned is the important and growing level of 'defensive expenditures', which are more in the nature of intermediate costs and should therefore not appear in GNP, although many are currently classed as final expenditure and therefore do so. Moreover, if GNP is to be a true figure of income, then not only does the depreciation of physical capital need to be deducted, as occurs in the computation of Net National Product (NNP), but the depletion of natural capital, or the costs of replacing such depletion with renewable substitutes, needs also to be subtracted if the (sustainable) income is not to be overstated. Finally, to the extent that the economy has become unsustainable, this represents accumulated costs in the past that should have been deducted from GNP, but were not.

Hueting et al. (1991) recommends that over all areas where environmental unsustainability is apparent, sustainability standards should be set and the cost of attaining them be deducted from GNP. Pearce et al. (1989, p. 108) recommends that for GNP to approach an indicator of sustainable income (or production, but not welfare), it should be subject to four subtractions: depreciation of manufactured capital, depletion of natural capital, household defensive expenditures, and the monetary value of residual pollution.

Were such adjustments to be made comprehensively, then much of the context of the 'limits to growth' debate would disappear because the new adjusted GNP simply would not grow in an economy that was fast depleting natural-capital or generating social and environmental externalities.

4. CONCLUSION

The debate about economic growth has focused attention on three extremely important sets of questions, which remain unanswered and extremely relevant today, concerning the current level and likely future increase of human economic activity. These questions are:

(a) Is such activity having an environmental impact which, at best, reduces the economic possibilities in the future and, at worst, is likely to precipitate widespread collapse? (The ecological sustainability debate.)
(b) Is such activity generating a range of negative social and environmental effects that actually outweigh many of the benefits of current affluence and of its nominal increase? (The welfare-from-growth debate.)
(c) Is such activity in market economies producing intense competitive and individualistic pressures that not only prevent individuals from enjoying their affluence, as in (b), but also undermine the cultural and moral fabric of society on which the economy itself actually depends? (The social sustainability debate.)

In the twenty years or so since these debates began in earnest, none of these questions have been conclusively answered in the negative. On the contrary, (a) now commands an almost universal positive response, which has given rise to UNCED, the largest inter-governmental conference ever held, and the ongoing concern with sustainable development. However, the debates have so far yielded nothing approaching consensus as to the ultimate relationships between economic growth and welfare or environmental or social sustainability.

It has, however, clarified some of the key parameters of these relationships. First, with regard to the environment, World Bank (1992, p. 9) sums up the basic conclusion thus: "Whether the limitations (of the earth's 'sources' and 'sinks') will place bounds on the growth of human activity will depend on the scope for substitution, technical progress and structural change."

It has been argued here that achieving possible reductions in environmental intensity and sustainable development will require different strategies in the North and South: more emphasis in the former on sustainability as a policy objective than on economic growth; and an emphasis in the latter on growth that is equitable and minimally environmentally damaging, with a combined focus on environmental regeneration, social reforms and careful industrialisation using the most environmentally advanced technologies. Such Southern growth will only be achieved in the context of reformed North–South economic relations. Maintaining the current undifferentiated emphasis on growth in both North and South is likely to increase unsustainability whatever the rhetorical commitments in favour of sustainable development.

Second, with regard to welfare, there can be no presumption that GNP growth, especially if it increases environmental destruction but even if it does not, increases social welfare. The relationship between GNP growth and welfare can only be elucidated by placing GNP in an operational indicator framework of economic welfare that goes well beyond it.

Third, with regard to social sustainability, it is quite possible that the type and pace of technological change required to make GDP growth and environmental protection compatible objectives, will exacerbate the sort of social problems identified by Mishan and Hirsch, with unpredictable results. These problems can only be addressed by explicitly exploring the moral and cultural issues raised by the predominant emphasis in economic thinking on individual preferences, self-interest, and competitive growth.

Such approaches provide an opportunity to invest the term 'sustainable development' with some deeper human, social and institutional significance, which may prove as important to its realisation as the mere development of and implementation of eco-technologies.

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