

**REFLECTIONS ON THE CONCEPT OF SUSTAINABLE  
ECONOMIC GROWTH**

**BY**

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# 12 Reflections on the Concept of Sustainable Economic Growth

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## 1 INTRODUCTION

Voltaire said that the English had a single sauce but many religions. The environmental movement, we might say, is a single religion with many sauces. The sauce de jour, however, is the concept of sustainable growth, popularized by the Brundtland Commission, which wrote:

Nature is bountiful, but it is also fragile and finely balanced. There are thresholds that cannot be crossed without endangering the basic integrity of the system. Today we are close to many of these thresholds; we must be ever mindful of the risk of endangering the survival of life on Earth.<sup>1</sup>

Many environmentalists believe that humanity is using up its natural endowments too rapidly. The natural endowments include appropriated non-renewable natural resources like energy resources, non-fuel minerals, and soils; appropriated renewable resources like forests and aquifers; and vital environmental resources like clean air and water, the stock of genetic material, and our present climate. The dangers range from mundane ones of mungy wastes to the more ominous ones of economic decline or even climatic apocalypse.

In response to the threats of premature exhaustion of our natural endowments, there has been a call to ensure 'sustainable growth'. This catchphrase has been endorsed by United Nations commissions<sup>2</sup> and by the World Bank.<sup>3</sup>

This paper is an inquiry into the significance of the concept of sustainable growth, applying this to the United States. At one level, sustainable growth is a commonsense reminder that we must take into account the long-run consequences of today's activities, that we must

not rob the future to benefit the present. In some writings, however, this concept has been interpreted in a manner that implies preservation of the existing environment and the need to slow or reverse economic growth. Section 2 of this paper examines the concept of sustainability as it has often been interpreted by ecological economists.<sup>4</sup>

The issue of sustainable growth revolves around intertemporal choice. At the most fundamental level, it involves three questions: the optimal overall level of investment in an economy, the optimal distribution of that investment (including areas involving disinvestment) across sectors, and the optimal distribution of consumption across space and across generations. Since these sound very much like traditional questions from economic growth theory, it is not surprising that economists have devoted considerable effort to studying the three underlying questions. To analyze these issues requires a notion of the objective function that economic growth should follow – a desideratum that would make a particular policy indeed ‘optimal’ – and in these pursuits economists typically rely upon the ‘Ramsey model’, in which the desirability of a path depends only on the discounted value of the utility of consumption.<sup>5</sup>

## 2 THE SUSTAINABILITY CRITIQUE: ORIGINS

In the last few years, environmentalists have rallied around the flag of sustainable development. The term gained prominence with the report of the Brundtland Commission, chaired by Gro Harlem Brundtland, former Prime Minister of Norway. This report, issued by the World Commission on Environment and Development, argued for designing policies to be sustainable, where sustainable development was defined as ‘development that meets the needs of the present without compromising the ability of future generations to meet their own needs’.<sup>6</sup>

The interpretation of this simple phrase has tested the creative exegesis of an army of analysts, and some of the interpretations challenge modern approaches to economic growth. A literal reading of the Brundtland definition just given would seem to be an endorsement of the Pareto criterion that this generation should meet the needs of the present as long as there is no reduction in the ability to meet the needs of the future. Unfortunately, while few would quarrel with the desirability of satisfying the Pareto criterion, it leaves an infinity of paths to choose from and it does not answer any of the dilemmas involved in choosing among the multitude of intertemporal growth paths.

## 2.1 The Rawlsean Interpretation

A common interpretation of unsustainability is as a decline in consumption; hence, sustainable growth policies are ones that leave future generations with a non-declining consumption path. This approach is generally inconsistent with the mainstream approach to economic growth in which a declining path would only be optimal in the face of declining endowments or technological regress.

The mainstream and sustainability approaches can be reconciled if we assume that society is extremely averse to intergenerational inequality, or if the coefficient of inequality aversion is extremely high. In the limit, as the coefficient of inequality aversion approaches infinity, the intertemporal social welfare function becomes indistinguishable from John Rawls's difference principle, in which 'economic inequalities are to be arranged so that they are . . . to the greatest benefit of the least advantaged'.<sup>7</sup> In the Rawlsean limit, consumption paths are constant if the technology is regressing, or society should be dissaving if technology is advancing.

The environmental application of the sustainability criterion did not, however, follow the Rawlsean limit of utility theory. Rather, the major line of analysis was to define sustainability in terms of non-declining consumption. This approach is clearly laid out in the thoughtful writings of David Pearce and his colleagues.<sup>8</sup> Pearce *et al.* first define development in terms of a vector  $D$  of social goals, where the elements of the vector include real per capita income, health and nutrition, education, access to resources, a 'fair' income distribution, and basic freedoms. The key definition is that 'sustainable development is then a situation in which the development vector  $D$  does not decrease over time'.<sup>9</sup>

This looks reasonable at first blush, but the complications proliferate on further reflection. All of the complications arise because the sustainability criterion reifies a particular objective (the non-declining development vector) and demotes all other objectives below that one.

### *Components of Sustainability*

The first issue is whether sustainability applies to all elements of the vector or to some appropriate utility index over the vector. This reduces to the familiar issues as to whether the social welfare function allows tradeoffs between, say, education and health, or whether some elements of the development vector are sacred and inviolable. Many people would hold certain basic freedoms to be sacrosanct, while a

biocentric viewpoint might hold the existence of major species to be beyond economic tradeoffs. Putting a firm constraint on some elements of the development vector would definitely constrain economic activity. For example, if an envirocentric view held that we must bequeath the present climate to the next generation, this would lead, I believe, to economic upheaval and political revolution. All this leads me to assume that the elements of the development vector must be substitutes, so that, for example, we will at least contemplate substituting per capita income for better health or access to resources for basic freedoms.

#### *Distribution of QOL*

Say that we have constructed a social utility index which is an acceptable utility function over the development vector – call it quality of life, denoted by  $QOL(D)$ . The sustainability requirement is that  $QOL(D)$  be non-decreasing over time. But we must also take into account individuality. To simplify, one would be tempted to create a social welfare function of the individual  $QOLs$ , so that our social objective would be  $W[QOL^1, \dots, QOL^n]$  for the  $n$  individuals.

But, as a second issue, we must consider whether the non-sustainability question applies to each individual person, everywhere and always. Even in the best of all conceivable worlds, someone will fall ill, someone's income will fall, someone will be unjustly refused an education, and someone will be unfairly incarcerated. So, to be operational, we must decide whether the sustainability criterion applies *ex ante* or *ex post*, for the average or the median or the 99.99th-percentile person, or for what. Once this is decided, are we sure that making the  $QOL$  index sustainable for the last person is worth making a very large number of people worse off? The difficulties of ensuring sustainability for each person are analytically identical to the difficulties of applying the Rawlsian difference principle over time.

#### *Uncertainty*

A third issue concerns the treatment of uncertainty. Say that we have agreed upon a social welfare function,  $W[QOL^1, \dots, QOL^n]$ , by which to measure whether a path is sustainable. But can we really know for sure? We are unsure about the exact trajectory of  $QOL$ . Perhaps climate change will be catastrophic, or perhaps it will head off a new ice age. Perhaps cold fusion will make energy too cheap to meter, or perhaps no clean non-fossil technology will be economical. Perhaps

human populations will continue to grow rapidly, or perhaps babies will become everywhere unfashionable. Perhaps human ingenuity will rescue us from our various constraints, or perhaps technology will stagnate.

The point is that we do not know *anything* that would meet the sustainability condition with certainty. This then raises a third problem, which is how to treat the potential of unsustainability. The sustainability criterion appears to hold that we would prefer a certainty of non-declining utility to a robust growth in utility plus a very tiny chance of a small decline in utility. How would we decide between path A, which had a 99 per cent probability of sustainability and a 1 per cent chance of extinction, and path B, which had a 95 per cent probability of sustainability and zero chance of extinction?

The point is that humanity faces many lotteries, not just 'sustainable' and 'unsustainable' ones. There are nasty sustainable paths, unpleasant unsustainable paths, and catastrophic unsustainable ones, and we surely would not be indifferent between them. To maximize the probability of sustainability might well give a high probability of extinction; this hardly seems a sensible outcome.

Reflection upon the issues of uncertainty will probably lead us to the conclusion that some sustainable paths are better than others and similarly for unsustainable ones. We would be silly to group paths into one pile labelled +1 for sustainable and another into -1 for unsustainable, for that approach would run into all the quandaries raised above. Rather, we would probably end up placing a consistent, continuous, and transitive ranking on different time paths for *QOL*. Indeed, we would soon find ourselves choosing among paths according to the expected utility approach, that is, maximizing the expected value of our *QOL* ranking of different paths.

The point of this analysis of the meaning of sustainability is to suggest that defining sustainability as non-declining consumption runs into the same issues that a Rawlsean approach would involve. Attempting to resolve these difficulties seems to lead to a compromise approach that has many of the features of the mainstream utilitarian approach. The compromise approach quacks like the utilitarian approach in aggregating different elements, it flies like the utilitarian approach in treatment of inequality, and it swims like the utilitarian approach in the treatment of uncertainty, so it is hard to see how the concept of sustainable growth adds significantly to our understanding of how to resolve the dilemmas of intergenerational equity.

## 2.2 The Hicksian Interpretation

If the concept of non-declining consumption paths is not a useful supplement to existing concepts, a second approach is potentially more useful. In their fascinating book on ecological economics, Herman Daly and John Cobb (see note 4) propose substituting the concept of 'Hicksian income' for GNP as a measure of sustainability.

Their approach is to ask for an operational definition of sustainability. They point to the definition of income by Hicks in *Value and Capital*: 'The purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves.'<sup>10</sup> Hicks then goes on to spell out a number of different approaches and ends with 'Income No. 1' as follows:

Income No. 1 is thus the maximum amount which can be spent during a period if there is to be an expectation of maintaining intact the capital value of prospective returns . . . ; it equals Consumption *plus* Capital accumulation.<sup>11</sup>

This definition of income – the maximum rate of consumption which *leaves capital intact* – is the central definition of Daly and Cobb as well as a number of other environmental critics and ecological economists.<sup>12</sup> In practice, this means that income equals consumption plus capital accumulation. Daly and Cobb and others have used the Hicksian definition to estimate sustainable income by taking consumption, adding capital accumulation, and subtracting an estimate of resource and environmental degradation.

In the discussion that follows, there are two separate issues that arise in the application of the concept of Hicksian income to sustainability at the national or global level. First is the difference between private and social income; the second is the issue of how to define the stocks of capital that should be left intact and how to estimate the value of stock changes.

### *(a) The Definition of Social Income*

The fundamental question is whether this interpretation of income (that is, Hicks's 'Income No. 1') is a useful approach for the valuation of *social* income as opposed to individual income. I would like to suggest in this section that the concept of 'keeping capital intact' is at

best treacherous and at worst inappropriate as a measure of social income.

To begin with, it must be noted that the underlying definition in Hicks is quite different from that cited by Daly and Cobb above. Income No. 1 is a *technique* for measuring income, but the more fundamental definition is actually in Hicks's Income No. 3:

Income No. 3 must be defined as the maximum amount of money which the individual can spend this week, and still expect to be able to spend the same amount *in real terms* in each ensuing week.<sup>13</sup>

In other words, real income is the largest constant real consumption annuity that can be generated by the current and future technology and stocks of capital, labour, and resources. Ignoring a number of technical issues,<sup>14</sup> Income No. 3 comes closest to a theoretically appropriate definition of income as the maximum sustainable level of consumption, so perhaps we can call Hicks the father of sustainable growth theory. In what follows, we call Hicks's Income No. 3 the 'consumption annuity' definition of income to distinguish it from Income No. 1, which is the 'capital intact' definition of income.

In analyzing various concepts of sustainable growth in a modern context, ecological and environmental economists have pursued the capital-intact over the consumption-annuity approach, often citing Hicks as the justification. While in certain circumstances the definition may be sensible, in practice it is defective.

First, the ecological interpretation of capital in the 'capital intact' definition has generally been too restrictive in including only capital assets. In Hicks, the meaning of 'capital' is as 'the capitalized value of the individual's prospective receipts'.<sup>15</sup> For the individual, this would contain not only the value of assets but the present value of labour income as well. By excluding human capital, 75 per cent of receipts are excluded. More important, in a society with technological change, the growth in productivity will be omitted from the calculation of capital and the value of income will be understated. Hence, the ecological implementation of Hicksian income has a downward bias because of the erroneous definition of capital. We return to this issue in the next section.

Second, it is not generally appropriate to identify social income with individual income. The consumption annuity definition of income is not a sensible definition of income for finite-lifetime agents;

it would imply that, for the last period of a consumer's lifetime, income equals wealth. Rather, the consumption annuity definition applies to what are (in principle) infinitely lived entities like societies or universities; indeed, the consumption annuity is the definition of income from endowment that universities often apply when they have no time preference. In addition, note that while individuals can use the (real) market prices of assets to measure accurately their consumption annuities, a nation's net worth does not translate into its assets for the purpose of calculating a consumption annuity.

A simple growth model will demonstrate these points. Assume that  $L(t)$  and  $K(t)$  are the stocks of labour and capital,  $Y(t)$  is the flow of gross output, which can be divided between consumption and homogenous capital.  $I(t)$  is gross investment, which equals  $sY(t)$ , while  $D(t) = \delta K(t)$  is the death of capital. Labour is exogenously growing at rate  $n$ , and there is labour-augmenting technological change at rate  $h$ . Examine the balanced-growth (or -decline) path. The economy is in steady-state with a growth (or decline) rate of output, capital, and augmented labour [ $e^{ht}L(t)$ ] of  $g = n + h$  and a constant real interest rate of  $r(t) = r^*$ .

Under the intact-capital definition of income (Hicks's Income No. 1, or  $I^1$ ), income at time  $t$  is equal to

$$I^1(t) = C(t) + I(t) - \delta K(t) \quad (1)$$

which is the standard definition of net national product. The consumption-annuity definition of income (Hicks's Income No. 3, or  $I^3$ ) is generally more complicated, although in the steady state it becomes simple. Conceptually, ( $I^3$ ) is given by

$$I^3(t) = \{ \max C^* \text{ such that } C(t) \geq C^* \text{ for all } t \} \quad (2)$$

From an accounting point of view, we would define social wealth,  $W(t)$ , as the present value of consumption:

$$W(t) = C(t)/(r^* - n - h). \quad (3)$$

With constant real interest rates or in a small open economy, this implies that the consumption annuity is given by

$$I^3(t) = r^*C(t)/(r^* - n - h). \quad (4)$$

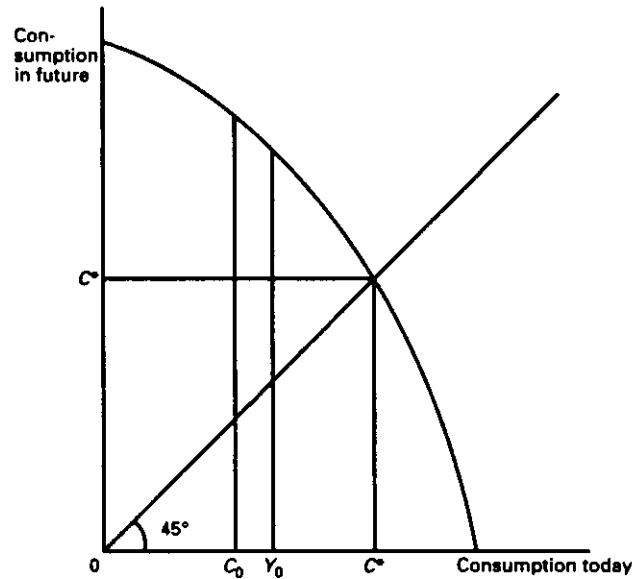


Figure 12.1 Alternative concepts of social income

Note:  $c_0$  and  $y_0$  are current consumption and net national output. Because of technological change, annuity consumption,  $c^*$ , is larger than net national output.

Note, however, that this will generally differ from the capital-intact definition if there is technological change. In general, in steady state the two definitions will be identical [ $I^1(t) = I^2(t)$ ] only when

$$C(t) + I(t) - \delta K(t) = r^*C(t)/(r^* - n - h) \tag{5}$$

For simplicity assume that labour is constant. In the absence of technological change, consumption equals net national product (NNP) and the two definitions of income are identical. With technological change, however, national wealth is larger than the capital stock, so  $I^2(t)$  will be greater than  $I^1(t)$ . The point is shown graphically in the Fisher diagram in Figure 12.1. This shows a country's consumption-possibility curve. The highest sustainable consumption ( $c^*$ ) exceeds current net national product ( $y_0$ ) and current consumption ( $c_0$ ) because of technological change.

This discussion shows the dilemma for the measurement of income. In a stationary economy, where production possibilities are not changing, both the intact-capital and the consumption-annuity definitions of social income give the same answer, which is NNP. However, in the presence of technological change, the consumption annuity will be higher than today's NNP; in effect, society's capital should include in its capital measure the growth of its 'knowledge capital', which is improving over time and is understated in the value of physical capital in conventional output measures.<sup>16</sup> In the literature on augmented accounts, there is a vast army of analysts involved in estimating the value of external *diseconomies* with hardly a squad concerning themselves with external *economies*, which after all have dominated economic growth for the last two centuries.

*(b) The Definition of Capital*

Among the different definitions of income, ecological and environmental economists have universally chosen Hicks's Income No. 1, and this approach seems to have been adopted by the United Nations.<sup>17</sup> A careful statement is made by Daly and Cobb in their theoretical justification of their numerical calculations:

Two adjustments to NNP are necessary to arrive at a good approximation to Hicksian income . . . One adjustment is a straightforward extension of the principle of depreciation to cover consumption of natural capital stocks depleted as a consequence of production. The other is to subtract defensive (regrettably necessary) expenditures made to defend ourselves from the unwanted side effects of growing aggregate production and consumption.<sup>18</sup>

Pearce, Barbier and Markandya take a more radical stance:

We now consider a key necessary condition for achieving sustainable development. . . . We summarize the key necessary condition as 'constancy of the natural capital stock'. More strictly, the requirement is for non-negative change in the stock of natural resources and environmental quality.<sup>19</sup>

The identification of a sustainable growth path with non-declining capital has three major shortcomings. First, as was shown in the last

section, a declining capital path can be rigorously associated with a declining consumption path only when technology is stationary. There is no indication that ecological or environmental economists hold that technological change is unlikely, although they may be sceptical of the ability of technological change to remove all environmental, resource, and ecological problems. But unless we believe that the Industrial Revolution has completely run out of steam, non-declining capital is not in fact identical with non-declining consumption possibilities.

A second and related feature of the ecological focus is the exaggeration of the importance of natural capital and the belittling of reproducible, human, technological, and scientific capital. Much is made of the depletion of stocks of oil and gas, for example, which are by far the most important appropriable, depletable natural resources. It is instructive to compare an estimate of the depletion of resources with tangible investment. An estimate of the appropriate amount necessary to correct for the depletion of subsoil assets (oil, gas, etc.) find that the correction is less than 1 per cent of the capital accumulation in tangible capital alone.<sup>20</sup>

The third point concerns the claim in Pearce *et al.* quoted above that the capital-intact definition should apply to 'natural capital' as well as to total capital. This assertion opens up the treacherous area of measuring income with heterogeneous capital, and we will make but a few comments on the assertion. To begin with, the authors recognize in other writings that the capital-intact criterion strictly applies to all tangible capital and not only to natural capital. They argue, however, that natural capital has in essence a higher claim. They reason that the actual natural capital stocks are lower than the optimal stocks in many countries (such as the Sahel). This is a factual issue, and surely is often correct, but it does not lead to the theoretical conclusion.

Next, they argue that natural capital stocks are generally undervalued, where this presumably applies to the market valuation of unappropriated (e.g., environmental) resources. While the statement may be technically correct in that there are no markets, and no estimates in most national accounts, for environmental resources, it is misleading as a prescription for policy. The fact that the market valuation of clean air is erroneous does not necessarily imply that the level of, say, sulphur abatement is too low. This would depend upon the regulatory regime; indeed, some would argue that for many conventional pollutants, the control levels are inefficiently high and that the 'optimal' policy would

be to reduce the 'natural capital' of non-sulphurous air. Moreover, in some areas, maintaining natural capital might be prohibitively expensive; my estimates suggest that maintaining the present climate would at best require devoting at least 10 per cent of global income to emissions reductions and at worst is infeasible.

In addition, in arguing for the need to maintain natural capital intact, ecological economists point to the existence of risks, uncertainties, and irreversibilities in natural capital. But surely these features are intrinsic to the investment process. Investments in natural capital such as tree farming hardly seem more irreversible than R&D investments in nuclear power or nuclear weapons; oil drilling is less risky than designing a new jumbo jet; and building new sewage plants seems humdrum compared to running an automobile factory in Russia. Natural capital has no natural monopoly on risk and irreversibility.

Finally, ecological economists sometimes argue that natural capital is 'essential' in the sense that its depletion would pose grave threats to society or life itself. Things do become genuinely more difficult in the case of essential and scarce natural capital. I have elsewhere examined optimal economic policy in the case of an essential and depletable natural resource.<sup>21</sup> Ironically, the sustainability paradigm has particular difficulty dealing with situations where a society has a finite stock of an essential resource and must allocate it over time. In such a situation the criterion of maintaining capital intact is unattractive because the only sustainable (capital-intact) path is immediate and permanent starvation. A more attractive path would be one in which the resource is gradually reduced as the stocks run down while society hunkers down to await a rescue from a technological breakthrough.

### 3 MEASUREMENT OF SUSTAINABLE INCOME

Like medieval religious disputations, many of the debates about sustainable growth appear to be abstract and without any obvious implications for economic policy. From time to time, however, economists have attempted to measure sustainable income as a way of determining whether our 'real' incomes are actually rising. Two decades ago, Jim Tobin and I constructed a Measure of Sustainable Economic Welfare, or MEW, for the United States.<sup>22</sup> From this exercise, we concluded that a measure of per capita income that is broader and more satisfactory had shown growth over the period 1929–65, albeit at a slower rate than did per capita NNP. Since then, there has been little enthusi-

asm for constructing broader national accounts in the United States, particularly in the US government, which has made essentially no contribution to this field. The exception has been the outstanding work of Robert Eisner in his development of TISA, or a Total Incomes System of Accounts.<sup>23</sup> Outside the US, both international organizations and the national governments of Norway, Germany, Japan, and France have developed augmented national accounts as a way of remedying the defects of existing national accounting conventions.

The most ambitious and comprehensive attempts to broaden the national accounts have been made by ecological economists, particularly Robert Repetto, Henry Peskin, and in the work of Daly and Cobb. The latter have produced a measure they call ISEW, or the Index of Sustainable Economic Welfare, which is an attempt to use a modified version of Hicks's Income No. 1. Although Daly and Cobb do not give a precise definition of their ISEW, it attempts to present an improved measure of social income based on the notion of sustainability. The basic scheme is similar to that of MEW: they begin with conventional measures of consumption, make additions for imputed items, and make subtractions for intermediate goods, regrettable necessities, and environmental degradation and other noisome features of modern life.

In work under way, I have attempted to compare different measures of national product and sustainable national income for the United States, taking into account some of the thoughts laid out in the first part of this study. Table 12.1 shows the preliminary results of this exercise. In that table, I have broken down the growth of the five major concepts of income – Gross National Product, Net National Product, Nordhaus and Tobin's Measure of Economic Welfare, Cobb and Daly's Index of Sustainable Welfare, Eisner's TISA, and a measure that follows the principles of Hicks's Income No. 1. The first group of numbers shows the estimates for the total while the second group shows the per capita estimates.

According to this calculation, Hicks's Income No. 1 appears to show roughly the same growth rates as do GNP or NNP, although growth was higher than GNP or NNP in the earlier period and slower in the later period. The reason for this result is that the corrections to GNP tend to wash out for the conversion of capital expenditures to capital services and that the environmental corrections are small relative to overall economic activity.

In addition, the growth of Hicks's Income No. 1 shows a more marked slowdown than do either GNP or NNP in the second part of

*Table 12.1* Comparison of growth rates of different income concepts, United States, 1950-86

<i>Income concept</i>	<i>1950-65</i>	<i>1965-86</i>	<i>Growth slowdown</i>
<i>Total Income Growth</i>			
Index of Sustainable Economic Welfare (ISEW)	3.81	1.02	-2.79
Measure of Economic Welfare (MEW)	2.07	na	na
Hicks Income No. 1	4.41	2.35	-2.06
GNP	3.75	3.05	-0.70
NNP	3.69	2.93	-0.77
TISA	3.19	2.05	-1.14
<i>Population growth</i>	1.63	1.05	-0.58
<i>Per Capita Income Growth</i>			
Index of Sustainable Economic Welfare (ISEW)	2.15	-0.03	-2.18
Measure of Economic Welfare (MEW)	0.43	na	na
Hicks Income No. 1	2.74	1.29	-1.45
GNP	2.09	1.98	-0.11
NNP	2.03	1.85	-0.17
TISA	1.54	0.98	-0.55

*Note:* TISA from Eisner (1989). The second period is 1965-81.

the period. By contrast, the slowdown in TISA growth is more modest than Hicksian income while ISEW slows extremely dramatically. For the second half of the period, the growth of Hicks's Income No. 1 per capita is about one-third less than either GNP or NNP.

It is useful to understand the reason for the deceleration in Hicks's No. 1 in the period since 1965. An examination of the major components of Hicks's Income No. 1 shows that the decline stems from a decline in the capital components rather than the environmental components. Changes in spending on consumer durables and the services of consumer durables, along with the net foreign dissaving, are the major components of the declining growth in income. The environmental and depletion components just about wash out, as the rewards from the nation's environmental investments reduce the damages about as much as the estimated disamenities increase it.

Clearly, this exercise is but a tentative attempt to put the concepts underlying sustainable growth on a quantitative plane. They suggest that the major source of decline in economic welfare for the United

States comes from conventional sources like declining productivity growth and dwindling saving rather than from the unsustainable use of our natural and human resources.

#### 4 CONCLUSIONS

This paper has examined the concept of sustainable growth from both a theoretical and an empirical point of view. What are the conclusions?

First, although the concept of sustainable growth has a superficial attractiveness – akin to the adage reminding ourselves not to eat all our capital or foul our nests – it contributes little new to mainstream approaches to intertemporal choice. The notion of a non-declining consumption path would seem to encounter all the paradoxes of Rawlsian and lexicographic preferences. Internal contradictions arise because a dichotomous evaluation into sustainable or unsustainable paths has difficulty handling issues of multiple criteria among the objectives, the distribution of unsustainability, and uncertainty.

Second, as applied by ecological economists, sustainability has often been interpreted as keeping capital (especially natural capital) intact. While this definition is useful for individuals, it is an inappropriate definition of social income except in a stationary economy. Moreover, the emphasis on maintaining natural capital has no general economic or ethical claim over human or reproducible capital.

Third, as an empirical matter, a tentative examination of a number of different concepts of income for the United States suggests that national-output growth has been overstated in the official national accounts. A new measure of national income – Hicksian Income No. 1 – shows significantly lower growth of income per capita than do either GNP or NNP. Moreover, the growth of augmented income per capita has slowed sharply over the postwar period. However, a decomposition of the growth slowdown finds that slow growth in private tangible capital along with foreign disinvestment are the chief sources of the slowdown in growth and that environmental corrections account for very little of the change in the rate of growth.

Is growth sustainable? Over the longer run, the answer to this question will depend upon the adequacy of our investment in human capital, knowledge, tangible capital, and to a lesser degree in natural and environmental capital. The shame of the current generation in America is, contrary to much popular opinion, that it has probably overinvested in seductive areas like pollution control, farmland protection, and military

R&D while underinvesting in dull areas like training, equipment, and applied research. This investment strategy is long in plants and mortars and short in plant and brainpower.

#### Notes

1. World Commission (1987), pp. 32ff.
2. World Commission (1987).
3. World Commission (1987).
4. 'Ecological economists' refers to a set of views at the intersection of ecology, economics and the environmental movement, see especially Daly and Cobb (1989).
5. Solow (1970), pp. 79–81.
6. World Commission (1987) p. 43.
7. Rawls (1971) p. 83.
8. See especially Pearce, Barbier and Markandya (1990).
9. Pearce, Barbier and Markandya (1990) p. 3.
10. Hicks (1948) p. 172.
11. Hicks (1948), pp. 173, 178. This discussion ignores the subtlety of Hicks's discussion of price changes, interest rate effects, the difference between *ex ante* and *ex post* capital and a number of other factors.
12. A more detailed discussion and application is presented in UN Statistical Office (1990).
13. Hicks (1948) p. 175.
14. Among the problems that still remain in this definition are index-number problems relating to the valuation of different consumption goods and the treatment of consumer durables and of uncertainty. Many of these complexities were considered by Samuelson (1961) in the Corfu conference volume that inspired the Varenna conference.
15. Hicks (1948), p. 172.
16. Weitzman (1976) has shown rigorously that NNP is the appropriate definition of social capital to include the value of all stocks of capital (including human capital and a mythical form of capital representing exogenous technological change); see also Dasgupta and Mäler (1991).
17. See Pearce, Barbier and Markandya (1990); Daly and Cobb (1989), Repetto, Wells, Beer and Rossini (1987); Pearce (1989) and UN Statistical Office (1990).
18. Daly and Cobb (1989), p. 71.
19. Pearce, Barbier and Markandya (1990) p. 4.
20. These estimates are presented in a background paper that explains the calculations in the following section.
21. Nordhaus (1992).
22. Nordhaus and Tobin (1972).
23. Eisner (1989).

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