Valuation and Evaluation: Measuring the Quality of Life and Evaluation Policy*

by

Partha Dasgupta
University of Cambridge, and
Beijer International Institute for Ecological Economics, Stockholm

Contents:

The Suntory Centre
Suntory and Toyota International Centres for
Economics and Related Disciplines
London School of Economics and Political Science
Houghton Street
DEDPS 22 London WC2A 2AE
November 1999 Tel: (020) 7955 6674

---

* This is a background paper prepared for the World Bank's annual World Development Report, 2000. In preparing it I have benefited from discussion with Gretchen Daily, Carol Dasgupta, Paul Ehrlich, Frank Hahn, Sean Holly, Simon Levin, Jane Lubchenco, William Peterson, Detlev Puertz, Peter Raven, Robert Rowthorn, Georgina Santos, and Paul Seabright. My greatest debt is to Karl-Göran Mäler, joint work with whom (Dasgupta and Mäler, 1999) is reported in the technical Appendix of this paper.

Abstract

This paper is about measuring social well-being and evaluating policy. Part I is concerned with the links between the two, while Parts II and III, respectively, are devoted to the development of appropriate methods of measuring and evaluating.

Keywords: Measuring social well-being; valuation, evaluation, policy, quality of life.

JEL Nos.: O2, P5, Q2.

Summary

This paper is about measuring social well-being and evaluating policy. Part I is concerned with the links between the two, while Parts II and III, respectively, are devoted to the development of appropriate methods of measuring and evaluating.

In Part II (Sections 4-7) I identify a minimal set of indices for spanning a general conception of social well-being. The analysis is motivated by the frequent need to make welfare comparisons across time and communities. A distinction is drawn between current well-being and sustainable well-being. Measuring current well-being is the subject of discussion in Sections 5-6. It is argued that a set of five indices, consisting of private consumption per head, life expectancy at birth, literacy, and indices of civil and political liberties, taken together, are a reasonable approximation for the purpose in hand.

Indices of the quality of life currently in use, such as UNDP's Human Development Index, are cardinal measures. Since indices of civil and political liberties are only ordinal, aggregate measures of social well-being should be required to be ordinal. In this connection, the Borda index suggests itself. In Section 6 the Borda index is put to work on data on what were 46 of the poorest countries in the early 1980s. Interestingly, of the component indices, the ranking of countries in the sample in terms of life expectancy at birth is found to be the most highly correlated with the countries' Borda ranking. Even more interestingly, the ranking of countries in terms of gross national product (GNP) per head is almost as highly correlated. There can be little doubt that this finding is an empirical happenstance. But it may not be an uncommon happenstance. If this were so, GNP per head could reasonably continue to be used as a summary measure of social well-being, even though it has no theoretical claims to be one.

It is widely thought that net national product (NNP) per head measures the economic component of sustainable well-being. In Section 7 and the Appendix it is shown that this belief is false. It is shown that NNP, suitably defined, can be used to evaluate economic policies, but that it should not be used in making intertemporal and cross-country comparisons of the standard of living. In particular, it is shown that comparisons of sustainable welfare should involve comparisons of wealth. For the purposes of comparing social well-being in an economy over time, this reduces to checking if net investment is positive or negative or nil. Writings on the welfare

economics of NNP have mostly addressed economies pursuing optimal policies, and are thus of limited use. The analysis in Section 7 and the Appendix generalizes this substantially by studying environments where governments are capable of engaging only in policy reforms, in economies characterized by substantial non-convexities. The analysis pertinent for optimizing governments and convex economies are special limiting cases of the one reported here.

Part III (Sections 8-10) is about policy evaluation. Policy evaluation techniques developed in the 1970s, while formally correct, neglected to consider (1) resource allocation in the wide variety of non-market institutions that prevail throughout the world, and (2) the role the environmental-resource base plays in our lives. In Part III it is argued that the evaluation of policy changes can be done effectively only if there is a fair understanding of the way socio-economic and ecological systems would respond to the changes. The observation is no doubt banal, but all too often decision-makers have neglected to model the combined socio-economic and ecological system before embarking upon new policies or keeping faith in prevailing ones. Examples are provided to show that such neglect has probably meant even greater hardship for precisely those groups of people who are commonly regarded as being particularly deserving of consideration. The examples are also designed to demonstrate how recent advances in our understanding of general resource allocation mechanisms and of environmental and resource economics can be incorporated in a systematic way into what are currently the best-practice policy evaluation techniques.

Part I

Reasons for Valuing and Evaluating

1. Means and Ends

In common parlance we use the term "valuation" when comparing objects, and "evaluation" when comparing the relative merits of actions. Of course, the objects needn't be concrete, they can be abstract (e.g. ideas). Nor is evaluation restricted to a narrowly construed notion of action. For example, we evaluate "strategies", which are conditional actions that can be personal or collective ("do this if that happens", "do that if he does this", and so forth). We also evaluate "policies", which too can be personal or collective. In this sense "valuation" is passive, while "evaluation" signifies more of an active engagement. We frequently "value" in order to be able to "evaluate"; but not always: we sometimes value simply because we wish to understand a state of affairs.

This article is about measuring the quality of life and evaluating policies. When discussing the latter, I shall be thinking of public policies, the sort of policies governments are expected to ponder over. They involve such matters as the character of public investment, the structure of taxes and transfers, environmental legislation, and so forth. To be sure, in speaking of the evaluation of public policies, I mean the evaluation of changes in public policies. Both valuation and evaluation involve comparisons. For example, when we ask if the standard of living in some country is currently higher than in some other, we are asking for a comparison. When we wish to evaluate a public policy, we have to compare it to some other policy, which typically would be the status quo; that is, the outcome which would prevail if existing policies were kept in place. Evaluation involves the consideration of counter-factuals.

The qualification "public" means two, often related, things. First, choice of one public policy, rather than another, implies one background environment, rather than another, within which the various parties in society can act. The choice influences the constraints to which the various parties are subject. So, evaluating a public policy requires that the likely responses of the economic system to the policy be assessed. Secondly, the evaluation needs to be conducted on behalf of a large, possibly disparate group of people, possessing different preferences, values, and needs. This calls for an acceptable procedure for aggregating the often conficting claims of members of the polity. It also requires that we identify those features of the consequences of the choice that are to be used to conduct the evaluation. In short, to be able to evaluate public

policies we need measures of the quality of life.

But as we have already noted, the need for quality-of-life indices arises not only because policies have to be evaluated, there are a number of other reasons. For example, we often wish to know if a group (e.g. women in a country) are doing as well today as they did in the past, or if one group (e.g. a country) enjoys a higher standard of living than another. In what follows, I am much concerned with such questions as these. One of my aims is to develop suitable indices for answering them. I also develop indices, based on quality-of-life measures, that would be appropriate for evaluating public policies. As we will see, the most suitable criteria for policy evaluation are not necessarily quality-of-life indices, even though, of course, the criteria are based on such indices.

The construction of quality-of-life indices has received considerable attention in recent years in such publications as the annual Human Development Report of the United Nations Development Programme (UNDP). But assessing the likely response of the economic system to policy choice is inherently the harder task. So, even although this article is about quality-of-life indices and policy-evaluation techniques, later in this essay (Part III, Section 10) I touch upon "institutional" responses to policy choice so as to highlight the fact that such responses affect the way policy evaluation should be conducted. In fact, it can be argued that, at the level of international discourse on development policies, disagreements stem largely from our common lack of understanding of the ways socio-economic and ecological systems respond to policy changes, they stem less from disagreements over what one might call "ethical values", in particular, they stem less from disagreements over what ought to be the ingredients of quality-of-life indices.

This last observation may appear odd. Economists continue to stress that people differ in their judgement on what are appropriate rates of trade-off among competing social goals. Political differences among people are to be traced to this, or so the assertion goes.[1] My own understanding is otherwise. Differences in people's

[1] Among the most prominent expositions of this view are Robbins (1932), Samuelson (1947), Graaff (1962), and Joan Robinson (1964).

opinions about how the world "works" assume importance in political debates long before differences in ethical views manifest themselves. I have yet to meet someone who does not wish to see unemployment reduced or destitution a thing of the past or current rates of disappearance of the rain forests stemmed. I have also heard many disagreements on what are the most effective means of bringing them about. As the philosopher Hilary Putnam has put it (Putnam, 1989, p. 7): "It is all well and good to describe hypothetical cases in which two people "agree on the facts and disagree about values", but ... (w)hen and where did a Nazi and an anti-Nazi, a communist and a social democrat, a fundamentalist and a liberal ... agree on the facts?"

It can also be argued that if development policies espoused by international bodies have not infrequently failed, they have failed because of our vastly imperfect knowledge and understanding of the way economic systems respond to policies, by which I mean, of course, the way people respond to policies and the way ecosystems respond to the treatment meted out to them. I don't know of much evidence that the failures were due to a wrong view of what constitutes economic progress. In short, even though we are generally in agreement about collective ends, we typically disagree about the right means to farther those ends. Later, in Part III (Sections 9-10), I provide examples of this. Nevertheless, even if there is wide-spread agreement on what counts as social well-being, there is need for an account of what this agreement amounts to. In the remaining sections of Part I and in Part II, I provide an account.

2. Whose Well-Being?

In what follows, I use the terms "well-being", "welfare", the "standard of living", and the "quality of life" interchangeably. I am interested here in measures of social well-being. I take it as understood that we are to build the measure from the ground up. Since the locus of sensation, perception, and feeling is at the individual level, it is appropriate to start there and to then build up. It is the individual who matters. I am setting aside here arguments that have been offered for treating all animals equally (Singer, 1976). Their acceptance would have far-reaching implications for many of our institutions. I am limiting myself to measures of human well-being.

A not infrequent criticism of the practice of founding measures of social well-being on individual well-beings is based on the thought that "the whole is greater than

the sum of the parts". Taken literally, this viewpoint is an acknowledgement that the processes which shape the way individual values and opportunities get translated into social outcomes are non-linear, with positive feedback. Usually, though, the thought is not taken literally, but is regarded more as offering a metaphor for the "body collective". Now those who espouse collectivist goals (e.g. national prestige) ought to be required to offer reasons why such goals are desirable. I don't know of any convincing reason which does not reduce to a concern over the individual members of the body collective (e.g. securing pride among members of the collective, thus enabling them to flourish cooperatively).

Disagreements between religious and secular people (and among religious people themselves) would also appear, ultimately, to be over facts (viz. over the existence, character and the will of God). Ethical differences stem from such disagreements. Religious tolerance encourages people to live their lives in the light of their own religious sensibilities, so long, that is, they do not infringe on the liberties of others. These are subtle and complex matters and have been much discussed over the centuries.[2] Their wide recognition today, which is perhaps the most far-reaching influence of the Enlightenment, is a reason why quality-of-life indices must include civil and political liberties.

These brief observations will be seen to have influenced the notion of social well-being I offer in Part II (Sections 4-8) of this essay. But the notion has also been informed by the overarching conception of citizenship, which is taken to cover three arenas: the civil, the political, and the socio-economic.[3] Recall that civil society is the sphere of autonomous institutions, protected by the rule of law, in which people may conduct their business freely and independently of the State. The civil element of citizenship consists of the right to justice.

Recall too that by the political element one means the right of a person to

[2] Russell (1946) is a concise reference.

[3] See T. H. Marshall (1964, pp. 71-2). Marshall's classic statement on the nature of social democracies is further advanced in Marshall (1981). Rawls' two principles of justice (Rawls, 1972) pertain to the production and distribution of three basic types of freedom: civil, political and socio-economic. Rawlsian justice concerns the fair distribution of what he calls "social primary goods", namely, liberty and opportunity, income and wealth, and the bases of self-respect (see especially, Rawls, 1972, p. 303).

participate in the exercise of political power, as a member of a body invested with political authority, or as an elector of the members of such a body. And, recall finally, that the socio-economic element is a range that encompasses the right to a certain share of resources, the right to share to the full in the social heritage, and to live the life of a civilized being commensurate with the standards prevailing in the society in question.

Quality-of-life indices in use today are based exclusively on the socio-economic sphere of citizenship (e.g. UNDP's Human Development Index; see UNDP, 1998). This is so limiting as to be potentially misleading. However, in Section 6, where I study data pertaining to the world's poorest countries, we will discover that an exclusive concern with the socio-economic sphere is not wildly misleading for the study of contemporary societies. To me this suggests that, in the world as we know it, the three elements of citizenship do not pull against one another, but rather that, generally speaking, strengthening one helps strengthen the others. If this were more widely true, and I have no reason to think otherwise, it would be an encouraging finding.

Thus, even although, in developing measures of social well-being, I will necessarily be thinking in aggregate terms, it bears stressing that the aggregate I consider is composed of aspects of the lives of individual people. To the extent people differ in their access to positions and opportunities owing to differences in their ethnic or religious background, certain consequences would seem to follow, such as the prevalence of communal strife. Since communal strife (in the extreme, civil war) is frequently both a cause and consequence of authoritarianism and corruption at the level of government, the inequalities can be seen manifested in a restriction of civil and political liberties. In other words, indices of civil and political liberties reflect inequities along ethnic or religious lines.

To the extent people differ in their access to basic goods and services owing to systematic inequalities in the socio-economic sphere (e.g. ownership of land), we would wish to place greater weight on those who lack ready access to them. So there is an explicit weighting system in any reasoned measure of social well-being.

In recent years much has been written on such weighting systems, for example, those which are embodied in such measures of inequality as the Gini coefficient (see,

for example, Sen 1992; UNDP, 1998; World Bank, 1998). In what follows, I build on this literature. So I take the literature for granted here. What I want to do, first of all, is to concentrate on the objects we would wish to study if we were to assess an individual's living standard. Aggregate well-being for a given cohort of people will then be regarded to be the average well-being of the cohort. The thought-experiment I invoke to do this is the now-familiar conception due to Harsanyi (1955), in which the standard of living in a society is deduced to be the expected living standard of someone who had equi-probability of finding themselves in the place of each member of society.[4] This is, of course, what practical measures frequently amount to (e.g. national income per head, and UNDP's Human Development Index (UNDP, 1991)). Inequality among a given cohort (e.g. between men and women, and between the poor and non-poor) can then be studied separately and additionally.

3. Why Measure Well-Being?

We need measures of social well-being for at least five purposes. First, there is need for an aggregate index of economic activity, of a kind which would help one to summarise a macroeconomy. Gross national product (GNP) has been found to be useful in this role. Secondly, we may wish to compare the states of affairs in different places (e.g. countries), or between different groups of people (e.g. the poor in comparison with the rich, or men in comparison with women), at a given point in time.

It is the case that in international publications the indices which are typically used for the second purpose reflect only the current living standard. For example, when the World Bank, in its annual World Development Report (e.g. World Bank, 1995), compares life expectancy at birth, infant survival rate, and public and private consumption per head across countries in a given year, one of the points of the exercise is to compare the current quality of life across countries (see the Appendix below, Proposition 3). However, in the same publication, countries are ranked in accordance with their GNP per head. The question is, why? Now it may be that the

[4] It will be recalled that Rawls' thought experiment was so constructed that average living standard was replaced by max-min living standard (Rawls, 1971). It will be noticed that the indices I work with below do not capture this thought-experiment exactly, but it does so with reasonably good approximation.

intention is to include in a summary measure a country's future prospects. Being the sum of aggregate consumption and investment, GNP may appear to be adequate for the task. The problem is that, as it doesn't include the depreciation of capital assets, GNP is incapable of reflecting future prospects (Section 9). GNP is not the flow equivalent of wealth (see Appendix below, Propositions 4-5). So it doesn't quite do to regard a country to be poor on grounds that its GNP per head is low. As a welfare measure, GNP per head is neither here nor there and no amount of finessing can rescue it. GNP is a measure of current economic activity and the prospects such activity brings with it, nothing more.

The third reason we need quality-of-life indices is that we frequently wish to make welfare comparisons over time of people in the same place (e.g. the same country) or members of a particular group (e.g. the poor or rich, suitably defined, or women). For example, we may ask if a country is doing better today than it did a decade ago, and so forth. This too is something the World Bank does in its annual World Development Report, when estimating changes over time in such indicators in a country as life expectancy at birth, infant survival rate, and public and private consumption per head (see, for example, World Bank, 1995). The idea there is to compare the current standard of living of a group of people at different dates (see Appendix below, Proposition 3).

The previous two reasons for the need for welfare indices focussed on measures which would reflect the current living standard. In contrast, the fourth reason stems from a desire to estimate the economic component of the standard of living an economy is capable of sustaining along alternative programmes. Early definitions of national income (Lindahl, 1934; Hicks, 1940; Samuelson, 1961; Weitzman, 1976) were designed to address this latter problem, and the bulk of recent theoretical explorations in green net national product ("green NNP") have returned to it.[5] It has been the claim of this literature that NNP per head (that is, GNP per head minus the per capita accounting value of the depreciation of all capital assets), is the measure we seek (see the references in the previous footnote). In the Appendix below, I show (Proposition 2

[5] See, for example, Solow (1986, 1992), Hartwick (1990, 1994), Asheim (1994, 1997), Aronsson, Johansson, and Löfgren (1997), Aronsson and Löfgren (1998), and Weitzman (1998).

and the remarks following it) that the claim is mistaken: NNP per head is inadequate for the task. I also show that per capita wealth, suitably defined, is the appropriate index. More particularly, it is demonstrated in the Appendix (Proposition 4) that if net investment per head is positive (negative), sustainable living standard increases (decreases). It may not be a coincidence that Adam Smith's classic was an inquiry into the wealth of nations, not the income of nations.

The thought then arises that per capita wealth can perhaps also be used in making cross-country comparison of sustainable living standards. In the Appendix (Proposition 6) I show that it can be so used, but only under what should be regarded as very strong assumptions. If the assumptions don't hold, there is no simple index adequate for the task. In Section 7 I present a non-technical account of these findings.

Finally, the fifth reason we seek a quality-of-life index is that we need ways to evaluate alternative economic policies. Criterion functions for social cost-benefit analysis of investment projects, such as the present discounted value of the flow of accounting profits (e.g. Dasgupta, Marglin and Sen, 1972; Little and Mirrlees, 1974; Squire and Van der Taak, 1975) are examples of such indicators (Section 8).

Since economic activity, the current quality of life, evaluation criteria for policy choice, and sustainable living standard are not the same object, their numerical measures are not necessarily the same. For example, in a market economy the wage bill for labour ought obviously to be included if the required index is to measure aggregate economic activity, as in GNP. But it is by no means obvious that the item ought to be included if the index is to measure social well-being (Nordhaus and Tobin, 1972; Dasgupta and Mäler, 1999; see the Appendix below). The moral is banal: the way an index ought to be defined, let alone estimated, is not independent of the purpose to which it is put.

But before all else, we should make clear to ourselves the purpose of the evaluation before undertaking it, and we should be prepared to conduct the evaluation as dispassionately as possible. Making good points with bad arguments may disguise the fact that there exist good arguments which would have served the purpose. Here is an example of the kind of mistake one makes when attempting an over-kill:

In drawing attention to the enormous inequality in today's world, UNDP (1998, p. 30) writes: "New estimates show that the world's 225 richest people have a combined wealth of over 1 trillion US dollars, equal to the annual income of the poorest 47 percent of the world's people (2.5 billion)."

It should be known that wealth is a stock and income a flow. Consequently, one should be converted into the other before the figures can be compared. The standard practice would be to convert wealth into a figure for permanent income by using a 5 percent annual interest rate, that is, to divide wealth by a factor of 20. When this conversion is performed on the data, my calculations, albeit they are very crude, tell me that the world's richest 225 people, having a combined annual income of over 50 billion US dollars, earn more than the combined annual incomes of people in the world's 12 poorest countries, or about 7 percent of the world's population (385 million). This is still a sobering piece of statistic.

It can be argued, of course, that if we seek a welfare indicator, we should measure well-being directly and not look for a surrogate and give it a different name, present discounted value of the flow of accounting profits, net national product (NNP), wealth, or whatever. There is something in this. On the other hand, as there are several reasons for seeking a welfare measure, for many purposes the most convenient index could be something other than the thing itself. For example, we could be interested in some object X, but X may prove especially hard to measure (e.g. because it involves estimating non-linear functions of observable quantities). Suppose now that for some purposes X is known to correlate perfectly with Y and that Y is easier to measure than X (e.g. because Y is a linear function of observable quantities). Then we would wish to rely on Y for those purposes. As is well known, wealth is linear in quantities, with the weights being at least in part revealed by observable market prices. This is the case also with the present discounted value of the flow of accounting profits. There lies the attraction of these indices.

Part II

Measuring Well-Being

4. Constituents and Determinants of Social Well-Being

The preceeding observation suggests that there are two ways of measuring social well-being. One is to study the constituents of well-being (e.g. health, happiness, freedom to be and do; more broadly, basic liberties); the other is to value the commodity determinants of well-being (goods and services which are inputs in the production of well-being; for example, food, clothing, potable water, shelter, and resources devoted to national security). The former procedure measures "output", for example, indices of health, and civil and political liberties, whereas the latter values and then aggregates the required "inputs", for example, expenditure on health, and resources deployed for the protection and promotion of civil and political liberties.[6] If undertaken with sufficient precision and care, either on its own would do the job (Dasgupta, 1993, Ch. 7*): changes in a suitable aggregate measure of either the constituents, or the determinants, can be made to serve as a measure of changes in the quality of life in a society. Along the former route we would measure the constituents directly and aggregate them in a suitable way, using social weights to reflect the relative worth of the various constituents (Dasgupta, Marglin and Sen, 1972). Along the latter route we would need to estimate accounting prices (see below) of the determinants of well-being in order to arrive at a suitable index for the purpose in hand, for example, wealth (see the Appendix, Proposition 4). As we have already observed, wealth is a linear function of the stocks of goods and services. This is why we frequently measure social well-being indirectly in terms of its determinants, rather than measure it directly in terms of its constituents.

In practice, neither the constituents nor the determinants, on their own, reflect what we wish to see captured in any reasoned conception of the quality of life. The problem is that there would be far too many person-specific accounting prices to contend with (e.g. those based on income distributional weights) if we were to estimate an overarching measure using only the determinants of social welfare. At the

[6] To be sure, there are goods, such as education and skills, which perform both functions: they are at once constituents and determinants of well-being. They do not pose problems if we are able to track the two functions and their contributions to well-being.

same time, a person's disposable income, as is customarily measured, does reflect aspects of welfare and the extent of certain patterns of freedom (viz. the freedom to choose over commodity bundles), matters which are hard to come to grips with directly. For this reason, governments and international agencies pursue both avenues at once, and it is today a commonplace to assess the quality of life by studying a heterodox collection of socio-economic indicators (see, for example, the World Bank's annual World Development Report, for example, World Bank, 1996; and the United Nations Development Programmes' annual Human Development Report, for example, UNDP, 1998). Earlier, we noted several weaknesses in the indices currently in use. So, in the following section I develop an index which overcomes some of their limitations.

Well-being isn't the same as happiness. One could be in a happy frame of mind under the influence of drugs and yet be in a state which could only be regarded as reflecting a low quality of life. This and other such examples have been much discussed in moral philosophy (see, for example, Sidgwick, 1907). Moreover, it is especially hard to get a quantitative feel for the experiential state associated with the sense of well-being. The nub is that states of mind are involved. Admittedly, other minds are not as inscrutible to one as they are commonly made out to be; one's own experiences provide the right source of information. Placing ourselves sympathetically in various possible situations is a way of obtaining the sort of information we seek.

We could, of course, study such objective indices as a country's divorce or suicide rate, so as to measure experiential states. This too has been suggested. But such indicators are seriously deficient. Divorce rates in a society may be low not because marriages are happy, but because the cost of divorce is, for women, prohibitively high. Similarly, the rate of suicide picks out features of the lower tail of the distribution of mental states. We would wish to know something about the entire distribution. A related approach would be to ask people if, on some specified scale (say, from 1 to 10), they were happy (see, for example, Frey and Stutzer, 1999). States of mind are not unmeasurable. In any event, whether we should include indices of the state of mind when evaluating a person's well-being depends on the point of the exercise. For example, contractarian theories of the State (e.g. Rawls, 1972; Nozick, 1974) typically

would not allow the State to be concerned with whether citizens were happy. Such theories would see the business of the State as being restricted to making sure that basic liberties are enjoyed.

This said, happiness is far too important a component of well-being to be bypassed. So it is a puzzle that the contemporary literature on social well-being simply ignores it. A prior question would be to ask what, in a normal state of mind, is conducive to happiness? Interestingly, at reasonably high levels of income, income would appear not to contribute much to happiness. Surveys in a number of western countries have revealed that substantial growth in per capita income has not translated into any significant increase in reported happiness (Easterlin, 1974; Scitovsky, 1976; Oswald, 1997). A natural conclusion to draw from this would be that, at relatively high levels of income, personal happiness depends on one's income or expenditure relative to the mean income or expenditure of some reference group (e.g., per capita national income; Easterlin, 1974). But I know of no comparable finding among the poor in poor countries and would be surprised if there were such findings to be found. It is hard to believe that at really low levels of income happiness isn't associated with income.

Studies suggest that health contributes significantly to happiness: other things being the same, healthy people are happier than those who suffer from ill health (see, for example, Frey and Stutzer, 1999). Studies in Europe also suggest that unemployment contributes significantly to unhappiness. Interestingly, in their study of a large sample from the various cantons of Switzerland, Frey and Stutzer (1999) have found that associational life plays a role too: people who are more engaged in civic activities are happier. Assuming that these findings are robust, indices of health, and civic and political liberties could serve as surrogates for happiness. In poor countries, consumption too would be presumed to be a surrogate. So if we were to include these indices in our measure of well-being, we would not need to introduce measures of happiness directly. This is the route I follow in the next section.

5. Measuring Current Well-Being

The problem, then, is to identify a minimal set of indices which would span one's conception of social well-being, be it current well-being or sustainable well-being. We have noted already that it is important to avoid double-counting. For

example, statistics on the proportions in populations not having access to potable water are in frequent use when depicting the quality of life, as are statistics on infant mortality rates. But the two would be expected to be highly correlated, indeed one is an important cause of the other. If one has the former (latter) piece of information, one doesn't need the latter (former) in constructing a quality-of-life index.

It has become customary to make cross-country and intertemporal comparisons of the quality of life in terms of current well-being. In this section we look at the issues that are involved in making such comparisons.

Begin with a person. In choosing an index of her standard of living, a balance has to be struck between the claims of completeness and costs. Leaving aside for the moment the extent of civil and political liberties she enjoys, there would seem to be at least three broad kinds of indices one can use in constructing a measure of her current well-being: her disposable income, her health status, and her educational attainments.[7] Now, these are different categories of goods. Health and education would seem to embody aspects of what are called "positive freedoms" (moreover, they are both ends and means), whereas disposable income contributes to the enjoyment of freedoms. So then why do we wish to mix them up here?

The reason is that someone's real disposable income measures the extent to which consumption goods like food and clothing, shelter, legal aid and general amenities are obtainable by that someone in the market. But primary health-care and education aren't this sort of goods. As improvements in primary health care and primary education give rise to wide-ranging "externalities" when they were privately supplied, private markets don't provide an ideal resource allocation mechanism for their supply. Markets for these goods need to be allied to an explicit support by the State, in a manner which assures citizens of their supply. Now government involvement in the provision of primary health-care and education varies enormously across poor countries. For this reason it is possible for people on average to enjoy a higher disposable income in one country, and yet suffer from worse health-care and education facilities than in another. Stating matters in the reverse way, it is possible for

[7] For a detailed discussion, see Dasgupta (1993, chs. 2-5).

people in one country on average to be better educated and to enjoy better health than in another even while their access to other material goods is more restricted (see Table 1, below). Disposable income, health and education indices reflect in their various ways the current socio-economic status of a person.

The move from the individual to the aggregate is frought with well-known difficulties. As I am focussing on (current) well-being, averaged over a population, I bypass inequality measures here.[8] A problem frequently overlooked concerns the legitimacy of moving from a person's disposable income, when thinking of a person's well-being, to a country's aggregate output per head, when reflecting upon social well-being. Thus, GNP per head continues to be regarded as the quintessential indicator of a country's living standard. The gigantic literature on the determinants of economic growth testifies to this, as do annual publications from international organizations. Even the Human Development Index of the United Nations Development Programme takes one of the components of the quality of life to be GNP per head.[9]

Personal income is the return on a person's wealth. But GNP is not the return on a nation's wealth. This will make for complications when, in Section 7, we come to develop the concept of sustainable living standard (see also the Appendix, below). As I am now interested in developing an index of the current standard of living, I have to ignore saving for the future. This leaves me with aggregate consumption, which consists of private and government consumption. But note that the latter is composed mainly of expenditures on health, education, and defense. We will measure the quality of health and education directly (by life expectancy at birth and literacy). This means that we would be counting health and education twice if we were to include government expenditure on them in our summary index. So we ignore such components of government expenditure.

This leaves us with defense, a central responsibility of government. But in poor countries, which is what I am in the main concerned with here, the machinary for

[8] The literature on distributional issues is vast (see Sen, 1992). Their consideration can be included in what follows by imputing person-specific weights to individual well-beings.

[9] The others are life expectancy at birth and literacy. See UNDP (1998). The Human Development Index has been finessed over the years so as to be, for example, sensitive to gender inequalities.

warfare is all too frequently used by governments against their own citizens. Moreover, what counts for citizens is their freedom to be and to do, a freedom which is generally compromised if national security is threatened. As civil and political liberties are prime components of the quality of life, we must include them explicitly. But this in turn means that we can ignore defense expenditure when constructing an index of the socio-economic component of social well-being.

Let me sum up: a minimal set of indices which would span one's conception of average well-being in a society would include private consumption per head, life expectancy a birth, literacy, and civil and political liberties.[10]

There remains the question of aggregating the five indices. Here we run into an interesting problem, one which has been greatly neglected in the literature on living standards. Indices which reflect the economic component of well-being are strongly cardinal, that is, they are scale invariant. For example, whether one measures private consumption in dollars or cents doesn't matter, so long as we remember that the latter is one-hundredth of the former. This enables us to say, for example, that someone's consumption rate is twice that of another person, or that someone today consumes three times as much as he did ten years ago, and so forth. But indices of civil and political liberties aren't like that, and cannot be like that. They are ordinal. It can make sense to say that the average citizen of some country enjoys greater civil liberties than the average citizen of some other country, or that civil liberties have increased in a country, but it makes no sense to say that civil liberties in one country are four times those in another, and so on. So we need an ordinal aggregator.

Of the many we could devise, the one best known and most studied is the Borda Rule. This rule provides a method of rank-order scoring, the procedure being to award each alternative (say, a country) a point equal to its rank in each criterion of ranking (the criteria being (i) per capita private consumption, (ii) life expectancy at birth, (iii) literacy, (iv) political liberties, and (v) civil liberties), adding each alternative's scores to obtain its aggregate score, and then ranking alternatives on the basis of their aggregate scores. To illustrate, suppose a country has the ranks i, j, k, l,

[10] For a more thorough justification of the choice of these indices, see Dasgupta (1993, chs. 2-5).

and m, respectively, for the five criteria. Then its Borda score is i + j + k + l + m. The rule invariably yields a complete ordering of alternatives. It can be viewed as a "social welfare function", since the criteria can be thought of as "voters". Of Arrow's classic axioms on social choice, the Borda Rule violates the one concerning the independence of irrelevant alternatives (Arrow, 1963). The strengths and limitations of the Borda Rule have been investigated by Goodman and Markowitz (1952) and Fine and Fine (1974). There is now a good intuitive understanding of it. So I use it for illustrating how one could make cross-country comparisons of the current quality of life if we are restricted to the use of ordinal indices, as we ought to be.[11]

6. Estimating Current Well-Being in Poor Countries

Our laboratory consists of countries which were in the early 1970s among the world's poorest in terms of income per head. The hope is to gain a preliminary understanding of the way the various components of well-being are related in today's world. Given the context in which such discussions have recently been undertaken, the restriction to the world's poorest countries is both deliberate and right.

We consider countries where in 1970 GNP per head was less than $1,500 at 1980 international dollars.[12] The idea is to look at a snap-shot of the quality of life in each country. The year in question is 1979-1980. I was able to obtain data on all five components of social well-being for only 46 out of the more than 55 countries which should be on our list. Table 1 summarizes the data. Since GNP per head is probably the most familiar international statistic, figures for this are provided in the first column of figures (but in parentheses, so as to remind ourselves that the country ranking on the basis of GNP per head is not being used in the construction of the Borda index).

The second column in Table 1 consists of estimates of private consumption per

[11] Of course, we could create a cardinal aggregator for the socio-economic indices (private consumption per head, life expectancy at birth, and literacy) and then construct the Borda ranking out of the three resulting rankings, namely, the rankings based on civil and political liberties and the socio-economic aggregate. In what follows in the text, I avoid creating complications by working directly with the five rankings.

[12] As the exercize that follows is purely illustrative, I have relied on data collated in Dasgupta and Weale (1992) and Dasgupta (1993). There per capita GNP was taken to be one of the socio-economic components of the quality of life. As I have just argued in the text (Sections 4-5), this was a mistake. So I have re-done the calculations by replacing per capita GNP by private consumption per head. This makes for some difference in the ranking of poor nations.

head in 1980. The third and fourth columns of figures present life expectancy at birth and literacy, respectively, again, for the year 1980.

The fifth and sixth columns of figures in Table 1 represent indices of political and civil liberties in our sample, for the year 1979. They are taken from the valuable compendium of Taylor and Jodice (1983). Rights to political liberty are taken to be the right on the part of citizens to play a part in determining who governs their country, and what the laws are and will be. Countries are coded with scores ranging from 1 (highest degree of liberty) to 7 (lowest degree of liberty). Values for this index are given in the fifth column of figures in Table 1.

Civil rights are different. They are rights the individual has vis-a-vis the State. Of particular importance in the construction of the index in Taylor and Jodice (1983) are freedom of the Press and other media concerned with the dissemination of information, and the independence of the judiciary. The index measures the extent to which people, because they are protected by an independent judiciary, are openly able to express their opinions without fear of reprisals. Countries are coded with scores ranging from 1 (highest degree of liberty) to 7 (lowest degree of liberty). Values of the index are given in the sixth column of figures.

Even a glance at the last two columns tells us that for the most part political and civil liberties were scarce goods in poor countries in the late 1970s. Citizens of 32 countries in our sample of 46 suffered from systems that score 5 or more for political rights, and those of no fewer than 39 countries from systems that score 5 or more for civil rights. Theis suggests that civil rights can be, and are frequently, curtailed in countries where elections are held. The scores reflect severe deprivation of basic liberties. There were exceptions of course, most notably Botswana, India, Mauritius and Sri Lanka. But for the most part the columns make for dismal reading. And when they are combined with the columns which reflect the socio-economic sphere of life, the picture which emerges is chilling. There was nothing to commend the state of affairs in a large number of the countries in our sample.

The first column in Table 2 presents the Borda ranking of nations, based on the rankings in the five columns that follow. Countries are listed in accordance with their Borda ranks. The ranking is from the worst (score of 1; Mali and Ethiopia being the

joint losers) to the best (score of 46; Mauritious being the winner). For completeness, country rankings on the basis of GNP per head are provided in the final column, in parentheses.

It is a useful exercize first to look at the best- and worst-off sets of countries. From the first column of figures, we note that in ascending order of aggregate well-being, the 10 lowest-ranked countries in 1980 were: Mali, Ethiopia, Niger, Mauritania, Chad, Malawi, Uganda, Burundi, Somalia, and Benin. How does this list compare with the ranking of nations based exclusively on GNP per head? To see this, we note from the final column that, in ascending order, the 10 poorest countries in terms of GNP per head were: Zaire, Uganda, Ethiopia, Burundi, Tanzania, Chad, Mali, Rwanda, Somalia, and Malawi. The lists aren't the same, but they are strikingly similar. All are in sub-Saharan Africa, and the lists contain seven countries in common.

Turning next to the ten highest-ranked countries, we note first that in terms of social well-being they are, in descending order: Mauritius, Sri Lanka, Ecuador, Korea, Paraguay, Thailand, Botswana, Bolivia and Morocco (tied), and the Philippines.

The relative positions of China on the Borda ranking (coming in at 17 from the top) and India (coming in five places ahead, at 12) deserves a brief comment. For a long while China and India have provided commentators with a classic tension: achievements in the economic sphere against those in the arena of political and civil liberties. As can be seen from Table 1, China beat India handsomely in each of the 3 socio-economic indices on our list (for example, private consumption per head in China in 1980 was more than twice that in India), while India beat China in political and civil liberties. All this is consistent with general knowledge. However, the fact that the two finish so close in a ranking of 46 countries means that the ordinal distance between them in political and civil liberties is large relative to their distance in terms of the socio-economic indicators. Other things remaining the same, had more countries managed to squeeze themselves in between China and India in the socio-economic indicators, the overall ranking of these two countries would have been reversed (recall that the Borda Rule violates the "independence of irrelevant alternatives" axiom in Arrow, 1963). On the other hand, had more countries squeezed themselves in between China and India in the sphere of political and civil liberties, the Borda gap between the

two countries would have been greater. Clearly then, the relative placings of China and India are sensitive to the aggregator being used. To me this is instructive.[13]

How does the list of the 10 top countries compare with the list of the 10 least poor countries. As it happens, they are very similar. The 10 least poor countries in our sample were, in descending order: Ecuador, Korea, Paraguay, Jordan, Tunisia, Thailand, China, the Philippines, Bolivia, and Mauritius. There are 7 countries in common. We conclude tentatively that, among the poorest of poor nations, rankings in terms of our index of aggregate well-being are not too different from their rankings based on income per head.

But this is a qualitative claim, and it will be informative to get a quantitative feel for the relationship between the Borda ranking and each of the rankings based on the five components of social well-being. Statistically, how close then is the Borda ranking to the other five? In order to examine this we look at rank correlations.

Table 3 provides the (Spearman) correlation coefficient for each pair of rankings from the seven rankings of nations in Table 2. It transpires that the correlation coefficient between the Borda ranking and the others are: 0.84 with private consumption per head; 0.88 with life expectancy at birth; 0.72 with literacy; 0.76 with political rights; and 0.75 with civil rights. I had not expected this. I had no reason to think that life expectancy at birth would be the closest to our measure of the quality of life.

At the same time, it is interesting that the Borda ranking of countries is highly correlated (0.87) with the ranking of countries based on GNP per head. The present findings imply that if we had to choose a single, ordinal indicator of aggregate well-being, either life expectancy at birth or GNP per head would do! There must be a moral to this.

In this paper I have argued that GNP per head should not be considered to be a

[13] In Dasgupta and Weale (1992) and Dasgupta (1993), where such computations were first undertaken, the socio-economic indices that were included were GNP per head, life expectancy at birth, infant survival rate, and literacy. Since life expectancy at birth is strongly influenced by infant survival, this amounted to counting similar health indices twice. It explains why, using what was essentially the same data set as Table 1, the two earlier studies found China to have a higher Borda score than India, the reverse of the present finding.

component of social well-being, that rather, private consumption per head should be. Not surprisingly though, the link between GNP and private consumption is close: in our sample, the correlation coefficient is 0.91. It is customary in studies of economic development to regress GNP per head against other socio-economic indicators, to see how closely they are related. The last row of figures in Table 3 presents Spearman rank correlation coefficients between GNP per head and each of the chosen five components of well-being. Ignoring private consumption per head, the highest correlation (0.83) is with life expectancy at birth. Again, I did not expect this. I also had no prior notion that correlation with literacy (0.61) would be considerably less.

Richer countries seemed to have enjoyed greater political and civil liberties. But the correlation is not overly high (the correlation coefficient between private consumption per head and political rights is 0.51 and with civil rights is 0.50). But neither private consumption per head nor political and civil liberties should be thought of as being exogenously given. Any such link between them as we observe in international data should only be seen as a link, nothing more. No causal relationship can be presumed from the data. However, correlation coefficients of 0.51 and 0.50 do mean that the claim that the circumstances which make for poverty are also those which make it necessary for governments to deny citizens their civil and political liberties is simply false. There are countries in the sample which are very poor in terms of private consumption and which enjoy relatively high civil and political liberties.

Literacy is a rogue index: it stands somewhat apart from the other socio-economic indices. The correlation coefficient between literacy and political and civil liberties are 0.28 and 0.30 respectively. These are relatively low figures, far and away the lowest figures in Table 3.

7. Wealth as Sustainable Well-Being

One may wonder where, if anywhere, net national product (NNP), suitably defined with all relevant accounting prices, comes in. Recall that GNP is an index of economic activity, including as it does "gross" capital formation, not "net". NNP is superior precisely on this count (Section 3). It reflects not only one of the economic components of current well-being (viz. consumption), it is sensitive also to the provisions currently made for the economic component of future well-being. In the

previous two sections we studied indices of current well-being. Here we study sustainable well-being (a formal definition of which is provided in the Appendix, Sections A.5-A.6). This requires of us to peer into future possibilities. For tractibility, I restrict our discussion to the socio-economic component of well-being, the implicit hypothesis being that civil and political liberties are a given. This isn't a good hypothesis, but there isn't anything I can do about it. We still lack an adequate overarching theory which relates "economics" to "political science". In particular, there is no workable model in which both future production possibilities and civil and political liberties are endogenous. So with hands tied behind the proverbial back, I consider intertemporal output and consumption possibilities, but not civil and political liberties. In the Appendix a canonical model of production and accumulation, involving labour, physical, knowledge, and environmental capital is presented. It enables us to draw a number of conclusions. The discussion here is based on findings arrived at in the Appendix.

What does NNP reflect? Following Weitzman (1976), NNP at any given date is widely thought to measure the sustainable standard of living made possible by an economy's assets at that date. Why might we be interested in such a result? We would be interested in it if it enabled us to make NNP comparisons, say between two dates, so as to infer how sustainable living standards compared between those same two dates. For example, if the Weitzman result were correct, we would conclude that sustainable living standard in a country had grown over a period if we were to observe that its NNP per head had grown over that same period.

In the Appendix below, I show that, alas, this cannot be done: unless an economy is in a steady state, NNP per head does not measure the sustainable standard of living (Proposition 2) in the sense that comparisons of NNP per head across time and communities do not amount to comparisons of the standard of living across time and communities (Propositions 4-7). This in turn means that NNP per head should not be used in making intertemporal or cross-country comparisons of well-being. I show that in order to make intertemporal comparisons of a community's sustainable living standard, the appropriate index is wealth (Propositions 4 and 6), which is another way of saying that, in making intertemporal comparisons of a community's sustainable

welfare, we should estimate if net investment has been positive, negative, or nil. Unfortunately, I am unable to conduct the kind of numerical investigation I was able to offer in Section 6: There are as yet only a few reliable country-estimates of the value of changes in natural capital over time. Nevertheless, there are reasons for thinking that many of the countries in sub-Saharan Africa have seen their assets decline during the past four decades or so. The development of international statistics on changes in the wealth of nations should now be a matter of urgency.[14]

The findings derived in the Appendix reflect the fact that NNP is not the flow equivalent of wealth. However, NNP, properly defined, can be used to evaluate short-term changes in economic policy. This is proved in Proposition 1 in the Appendix. To be sure, if NNP is to be used for the purposes of policy evaluation, accounting prices should be used. Recall that the accounting price of a resource is the increase in social well-being if a unit more of the resource were made available costlessly. Assume for simplicity that labour is supplied inelastically (in the Appendix I drop this assumption). In this case, NNP in a closed economy, when correctly measured, reads as:

NNP = Consumption + net investment in physical capital + the value of the net change in the stock of natural capital - the value of current environmental damages.[15]

Notice that the value of net changes in human capital and knowledge are included implictly in the first two terms in the formula for NNP. It is useful also to note that the convention of regarding expenditures on public health and education as part of final demand implicitly equates the cost of their provision with the contribution they make to social well-being. This in all probability results in an underestimate in poor countries. If education were a constituent of the standard of living, and not merely a determinant through being instrumental in raising productivity, then its accounting price would be that much higher. We should note as well that current defensive expenditure against damages to the flow of environmental amenities ought

[14] Serageldin (1995) has reported empirical work conducted at the World Bank on measuring changes in wealth (see also World Bank, 1996).

[15] In an open economy the value of net exports ought to be deducted from the equation. See Sefton and Weale (1996).

to be included in the estimation of final demand. Similarly, investment in the stock of environmental defensive capital should be included in NNP. These, and a number of other rules for constructing national accounts are proved in the Appendix. In the remainder of this essay I explore methods appropriate for evaluating policy change.

Part III

Evaluating Policy

8. Valuing Goods and Evaluating Projects

Policy changes are perturbations to a prevailing state of affairs. Investment projects can therefore be interpreted as policy changes. A project consisting of a dam would be a perturbation to an economy without the dam. The economic forecast without the project can be thought of as the status-quo. We could, of course, analyse the consequences of a policy change in terms of their impact on the constituents of social well-being. But as I argued earlier, there are advantages in analysing them in terms of their impact on the determinants of social well-being. The linear indices I have been alluding to, such as the present discounted value of the flow of accounting profits from a project, work most effectively if the perturbation being evaluated is "small".[16] What constitutes "smallness" is a delicate matter and the project evaluator has to be sensitive to it. An investment project can be small in terms of a country's NNP and yet have a big impact on the lives of some very poor people; in which case it wouldn't be small for them. The way to proceed would be to estimate the net benefits the people in question would experience if the project were undertaken. The net benefits would typically be non-linear functions of quantities.

In evaluating an investment project, the need for labour, intermediate products, and raw materials is estimated, and the project's output and its impact on the ecological system are predicted, quantitatively, for each period. Most often, though, one does not have sufficient knowledge to make precise estimates of the consequences. One therefore needs quantitative estimates of the uncertainties, preferably in terms of probabilities. This means that, in general, one has to model the integrated ecological and economic system.[17] The evaluation procedure involves estimating the impact of projects on human well-being - now and in the future. In order to arrive at an estimate, each and every commodity of the project has to be valued in terms of some numeraire (e.g. consumption, as in the formula for NNP in Section 7). The accounting price of a commodity or service is measured by its social opportunity cost in terms of the numeraire. These steps are common to all methods of evaluation.

---

[16] Formally, we are then able to limit ourselves to the first-order approximations of the perturbations.

[17] See Daily et al. (1999) for an elaboration of this step.

If we wish to assess the impact on social well-being of a brief policy change (e.g. a short-term investment project), then, as we noted in Section 7, the effect of the change on NNP (suitably defined) could be used for evaluating the worthwhileness of the change (Appendix, Proposition 1). For long-lasting projects the most useful criterion is the present discounted value of the flow of accounting profits. To estimate this, one first computes the net social profit of a project in each period of its life. The net social prifit, in turn, is obtained by multiplying the project's inputs and outputs in the period in question by their corresponding accounting prices and adding them (outputs are taken to be positive, inputs are taken to be negative). Using a suitable discount rate, often called the "social rate of discount", the per period net social profits yielded by a project are added.[18] Projects which yield a positive present discounted value of net social profits are then recommended, those which yield a negative present discounted value of net social profits are rejected.

Procedures for estimating the accounting prices of goods and services were much discussed at the World Bank in the 1970s (see, for example, Squire and Van der Taak, 1975). The theory of accounting prices that existed at that time assumed in effect that the economy in which social cost-benefit analysis is conducted has an optimal economic policy in place -, perhaps a second-best policy, but an optimal policy nonetheless. This was assumed explicitly in Little and Mirrlees (1974). In contrast, Dasgupta, Marglin and Sen (1972) developed prescriptions for project evaluation in economies where projects could be thought of as policy reforms, that is, perturbations to economic forecasts that may be riddled with inefficiencies and inequities. However, they offered no formal theory to justify their prescriptions for an economy moving through time.[19] Theoretical foundations of social cost-benefit analysis when investment projects are policy reforms have since been developed by Dasgupta and Mäler (1999). The theory is presented in the Appendix below. It is important to stress that the theory

[18] The social rate of discount in any period is the percentage rate of decrease over that period and the next in the accounting price of the numeraire.

[19] Projects as policy reform have been studied also by Meade (1955), Mäler (1975), Starrett (1988), Ahmad and Stern (1990) and Dreze and Stern (1990). But their analysis was limited to what were esentially timeless economies.

does not presume economies to possess a convex structure: production non-convexities arising from economies of scale and scope and from ecological thresholds can be accomodated. This is a significant improvement on earlier theories, which relied heavily on the assumption that economies possess a convex structure.

What would those valuation techniques developed in the 1970s and extended recently instruct us if they were put to work on current concerns? In a recent lecture, the President of the World Bank has correctly observed that, "... the success of most projects is dependent on many assumptions extraneous to the project itself. Building new schools is of no use without roads to get the children to the schools and without trained teachers, books and equipment... Initiatives to make progress creating equal opportunities for women make no sense if women have to spend many hours each day carrying clean water, or finding and gathering fuel for cooking. Seeking universal primary education without prenatal and postnatal health care means that children get to school mentally and physically damaged. Establishing a health system but doing nothing about clean water and sewerage diminishes enormously the impact of any effort." (Wolfensohn, 1999, p. 8.)

The author is pointing at the need to understand an economic system's response to project selection. His examples are about complementarities. Just as a shoe for the left foot is useless without the corresponding shoe for the right foot, establishing a health system, but doing nothing about clean water, would not amount to much. The accounting price of an object whose complements are unavailable is low, in the extreme it is nil. Projects which produced one without its complements would register a negative present discounted value of social profits. In short, an integrated project could pass the test even when its components, each on its own, would not.

9. The Environmental-Resource Base[20]

A significant weakness of the several manuals on social cost-benefit analysis that were written during the 1970s was their total neglect of the natural world around

[20] Some of the material of this section is taken from Dasgupta (1993) and Dasgupta, Levin and Lubchenco (1999).

us. The environment simply didn't get a look in.[21] Since market failure abounds in our dealings with the environment, markets cannot be relied upon to provide us with prices which would even approximately signal the social scarcities of environmental resources. A great deal of work in environmental and resource economics since the 1970s has been directed at discovering methods for estimating the accounting prices of various types of environmental resources. But in considerable measure practical methods have been developed for estimating the accounting prices of "amenities" (see, for example, Mitchell and Carson, 1989; Freeman, 1992), much less so for the multitude of ecosystem services which constitute our life-support system, such as pollination, recycling of biomass, nitrogen fixation, and water purification. We also lack a systematic body of work on valuation techniques appropriate for the many non-market institutional settings in which environmental resources are known to be transacted.

However, the following is even now abundantly clear. Indicators of social well-being in frequent use (e.g. GNP per head, life expectancy at birth, and the infant survival rate) do not reflect the impact of economic activities on the environment and the latter's response to the treatment meted out to it. Since such indices as GNP per head pertain to commodity production, they don't fully take into account the use of natural capital in the production process. So, statistics on past movements of GNP tell us nothing about the resource stocks that remain. They don't make clear, for example, whether increases in GNP per head are being realized by means of a depletion of the resource base (for example, if increases in agricultural production are not being achieved by means that adversely affect the services ecosystems are capable of providing us). Over the years environmental and resource economists have shown how national accounting systems need to be revised so as to include the value of the changes in the environmental resource-base that occur each year due to human activities (see, for example, Mäler 1974; Dasgupta and Heal 1979; Dasgupta and Mäler, 1999). We should be in a position to determine whether resource degradation in the

[21] Dasgupta (1982) was an attempt to put that right.

various locations of the world has yet to reach the stage from which their current economic activities are unsustainable. But the practice of national-income accounting has lagged so far behind its theory, that we have little idea of what the facts have been. It is entirely possible that time trends in such commonly used socio-economic indicators as GNP per head, life expectancy at birth, and the infant survival rate give us a singularly misleading picture of movements over time of the true standard of living.

To state the matter in another way, current-day estimates of socio-economic indicators are biased because the accounting value of changes in the stocks of natural capital are not taken into account. Because their accounting prices are not available, environmental resources on site are frequently regarded as having no value. This amounts to regarding the depreciation of natural capital as of no consequence. But as these resources are scarce goods, their accounting prices are positive. If they depreciate, there is a social loss. This means that profits attributed to projects which degrade the environment are frequently greater than the social profits they generate. Estimates of their rates of return are higher than their social rates of return. Wrong sets of investment projects therefore get selected, in both the private and public sectors: resource-intensive projects look better than they actually are. It should be no surprise, therefore, that installed technologies are often unfriendly towards the environment. This is likely to be especially true in poor countries, where environmental legislations are usually neither strong nor effectively enforced.

The extent of such bias in investment activities will obviously vary from case to case, and from country to country. But it can be substantial. In their work on the depreciation of natural resources in Costa Rica, Solorzano et al. (1991) estimated that in 1989 the depreciation of three resources — forests, soil, and fisheries — amounted to about 10 percent of gross domestic product and over a third of gross capital accumulation.

One can go further: the bias extends to the prior stage of research and development. When environmental resources are underpriced (in the extreme, when they are not priced at all), there is little incentive on anyone's part to develop technologies which would economize their use. So the direction of technological

research and technological change are systematically directed against the environment. Consequently, environmental "cures" are sought once it is perceived that past choices have been damaging to the environment, whereas "prevention", or input reduction, would have been the better choice. To give an example, Chichilnisky and Heal (1998) compared the costs of restoring the ecological functioning of the Catskill Watershed ecosystem in New York State, to the costs of replacing the natural water purification and filtration services the ecosystem has provided in the past by building a water-purification plant costing 8 billion US dollars. They showed the overwhelming economic advantages of preservation over construction: independent of the other services the Catskill watershed provides, and ignoring the annual running costs of 300 million US dollars for a filtration plant, the capital costs alone showed a more than 6-fold advantage for investing in the natural-capital base.

But bad habits are hard to overcome. Even today the environment has not entered the common lexicon of economic discourse. Accounting for the environment, if at all it comes into the calculus, is an after-thought to the real business of "doing economics". Thus, for example, a recent issue of The Economist (25 September 1999) carries a 38-page Survey of the World Economy in which the environmental-resource base makes no appearance in the authors' assessment of what lies ahead. But we are all so ingrained in our habits that I rather doubt if many readers will have noticed this fact.

It is worth emphasizing that the purpose of estimating environmental accounting prices is not to value the entire environment; rather, it is to evaluate the benefits and costs associated with changes made to the environment due to human activities. Prices, whether actual or accounting, have significance only when there are potential exchanges from which choices have to be made (for example, when one has to choose among alternative investment projects). Thus, the statement that a particular act of investment can be expected to degrade the environment by, say, 1 million dollars annually has meaning, because it says, among other things, that if the investment were not to be undertaken, humanity would enjoy an additional 1 million dollars of benefits in the form of environmental services. The statement also has operational significance: the estimate could (and should) be used for calculating the

present discounted value of the flow of social profits attributable to the investment in question.

Contrast such an estimate of the value of an incremental change in the environmental-resource base with the one which says that, world-wide, the flow of environmental services is currently worth, in total, 33 trillion US dollars annually (Costanza et al., 1997). The former is meaningful because it presumes that humanity will survive the incremental change and be there to experience and assess the change. The reason the latter should cause us to balk is that if environmental services were to cease, life would not exist. But then who would be there to receive 33 trillion US dollars of annual benefits if humanity were to exchange its very existence for them? This is a case where, paradoxically, the value of an entire something has no meaning and, therefore, is of no use, even though the value of incremental changes to that same something not only has meaning, it also has use.

An approach similar to Costanza et al. (1997) appears in a Focus article in The Economist (26 June 1999). In observing the disturbing tendency of compound interest to make large figures in the distant future look very small today, it is remarked (p. 128): "Suppose a long-term discount rate of 7 percent (after inflation) is used ... Suppose also that the project's benefits arrive 200 years from now ... If global GDP grows by 3 percent a year during those two centuries, the value of the world's output in 2200 will be 8 quadrillion US dollars (a 16-figure number). But in present-value terms, that stupendous sum would be worth just 10 billion US dollars. In other words, it would not make sense for the world to spend any more than 10 billion US dollars (under 2 US dollars a person) today on a measure that would prevent the loss of the planet's entire output 200 years from now."

We have already seen one problem with this reasoning. Another is its presumption that social rates of discount are independent of the income forecast whose perturbation is being discounted. The underlying assumption in the passage is a massive perturbation (zero world output in year 2200). This would involve a secular decline in output, at least from some point in time in the future. But social discount rates associated with declining consumption streams would be expected to be

negative.[22] When viewed from the present, negative discount rates amplify incomes in the distant future, they don't shrink them. Discounting future incomes produces paradoxes only when it isn't recognised that, as discount rates are themselves accounting prices, they should be endogenous to the analyses, the rates cannot be plucked out of the air.

10. Institutional Responses to Policy Change

It is easy enough to define policy change (for example, an investment project) as a perturbation to an economic forecast. It is altogether a more difficult matter to identify what the perturbation actually consists of. Any system, human or otherwise, should be expected to respond when subjected to a perturbation. In an economy that is not pursuing an optimum policy, a policy change can create all sorts of effects that ripple through without being noticed by the public offices, for the reason that there may be no public "signals" accompanying them. Tracing the ripples requires an understanding of the way markets and non-market institutions interact.

Very many transactions take place in non-market institutions. A prime set of examples are transactions involving environmental services. In poor countries further examples abound. In recent years long-term relationships have been studied by economists and political scientists with the same care and rigour that they used to invest in the study of markets and the State. There is now a large and illuminating theoretical and empirical literature on the wide variety of ways in which people cope with resource scarcity when there are no formal markets for exchanging goods and services across time, space, and circumstances.[23] The literature offers us a lever with which to predict, in broad terms, the way people, both individually and communally, would respond to policy changes. Unfortunately, the literature hasn't filtered through sufficiently to decision-makers. I want to illustrate what I mean by providing two examples, one a local miniature, the other altogether grander and near-global.

For many years now, the political scientist, Elinor Ostrom, has been studying

[22] See Dasgupta and Mäler (1995, pp. 2,400-1) for why this would be so.

[23] I have gone into this literature in detail in Dasgupta (1999).

the management of common-property resources in various parts of the world. In her work on collectively-managed irrigation systems in Nepal (Ostrom, 1996), she has accounted for differences in rights and responsibilities among users (who gets how much water and when, who is responsible for which maintenance task of the canal system, and so forth) in terms of such facts as that some farmers are head-enders, while others are tail-enders. Head-enders have a built-in advantage, in that they can prevent tail-enders from receiving water. On the other hand, head-enders need the tail-enders' labour for repair and maintenance of traditional canal systems, which are composed of temporary, stone-trees-and-mud headworks. This means that both sets of parties can in principle gain from cooperation. However, in the absence of cooperation their fortunes would differ greatly. So, cooperative arrangements would be expected to display asymmetries, and they do so display.[24]

In Ostrom (1996), the author reported that a number of communities in her sample had been given well-meaning aid by donors, in that the canals had been improved by the construction of permanent headworks. But she observed that those canal systems that had been improved were frequently in worse repair and were delivering less water to tail-enders than previously. Ostrom also reported that water allocation was more equitable in traditional farm-management systems than in modern systems managed by external agencies, such as government and foreign donors. She estimated from her sample that agricultural productivity is higher in traditional systems.

Ostrom has an explanation for this. She argues that unless it is accompanied by counter-measures, the construction of permanent headworks alters the relative bargaining positions of the head- and tail-enders. Head-enders now don't need the labour of tail-enders to maintain the canal system. So the new sharing scheme involves even less water for tail-enders. Head-enders gain from the permanent structures, but tail-enders lose disproportionately. This is an example of how well-meaning aid can go wrong if the institution receiving the aid is not understood by the donor.

[24] In fact, a general finding from studies on the management of common property systems is that entitlements to products of the commons is, and was, almost always based on private holdings. See McKean (1992) and Ostrom and Gardner (1993).

Resource allocation rules practised at the local level are not infrequently overturned by central fiat. A number of States in the Sahel imposed rules which in effect destroyed communitarian management practices in the forests. Villages ceased to have authority to enforce sanctions on those who violated locally-instituted rules of use. State authority turned the local commons into free-access resources.

My second example is altogether more grand and fiercely debated. So, of course, I will be a lot more tentative in what I say. It has to do with the experience people in poor countries have had with structural adjustment programmes, which involved reductions in the plethora of economic distortions that had been introduced by governments over decades.

Many have criticised the way structural adjustment programmes have been carried out. They have pointed to the additional hardship many of the poor have experienced in their wake. But it is possible to argue that structural adjustments, facilitating as they did, the growth of markets, were necessary. And it has been so argued by proponents of the programmes. What I want to suggest is that both proponents and opponents of the programmes may be right. Growth of markets benefit many, but they can simultaneously make vulnerable people face additional economic hardship and thereby increase the incidence and intensity of poverty and destitution in an economy.

How and why might this happen? There are a number of pathways by which it can happen. Here I will sketch one that I have developed in previous writings (e.g. Dasgupta, 1993, 1999).

Long-term relationships in rural communities in poor countries are typically sustained by the practice of social norms, for example, norms of reciprocity. This isn't the place to elaborate upon the way social norms should technically be viewed (as self-enforcing behavioural strategies). The point about social norms which bears stressing, however, is that they can be practised only among people who expect to encounter one another repeatedly in similar situations.

Consider then a group of "far-sighted" people who know one another and who prepare to interact indefinitely with one another. By a far-sighted person I mean now someone who applies a low rate to discount future costs and benefits of alternative

courses of action. Assume as well that the parties in question are not separately mobile (although they could be collectively mobile, as in the case of nomadic societies); otherwise the chance of future encounters with one another would be low and people (being far-sighted!) would discount heavily the future benefits of current cooperation.

The basic idea is this: if people are far-sighted and are not separately mobile, a credible threat by all that they would impose sufficiently stiff sanctions on anyone who broke the agreement would deter everyone from breaking it. But the threat of sanctions would cease to have potency if opportunistic behaviour were to become personally more enticing. This can happen during a process in which formal markets grow nearby and uncorrelated migration accompanies the process. As opportunities outside the village improve, those with lesser ties (e.g. young men) are more likely to take advantage of them and make a break with those customary obligations that are enshrined in prevailing social norms. Those with greater attachments would perceive this, and so infer that the expected benefits from complying with agreements are now lower. Either way, norms of reciprocity could be expected to break down, making certain groups of people (e.g. women, the old, and the very young) worse off. This is a case where improved institutional performance elsewhere (e.g. growth of markets in the economy at large) has an adverse effect on the functioning of a local, non-market institution. To the extent local common-property natural resources are made vulnerable by the breakdown of communitarian control mechanisms, structural adjustment programmes would have been expected to be unfriendly also to the environment and, therefore, to those who are directly dependent on them for their livelihood. This is because when the market value of a resource-base increases, there is especial additional pressure on the base if people have relatively free access to it.[25] Structural adjustment programmes devoid of safety-nets for those who are vulnerable to the erosion of communitarian practices are defective. They can also be damaging to the environment unless the structure of property rights, be they private or communitarian, is simultaneously made more secure. We should not have expected

[25] See Dasgupta (1990) for a theoretical analysis; and Reed (1992) for an empirical investigation, in three poor countries, of some of the effects of structural adjustment programmes on resource bases.

matters to have been otherwise.[26]

11. Conclusions

This paper has been about measuring social well-being and evaluating policy. Part I was concerned with the links between the two, while Parts II and III were devoted, respectively, to the development of appropriate methods of measuring and evaluating.

In Part II (Sections 4-7) I identified a minimal set of indices for spanning a general conception of social well-being. The analysis was motivated by our frequent need to make welfare comparisons across time and communities. A distinction was drawn between current well-being and sustainable well-being. Measuring current well-being was the subject of discussion in Sections 4-6. It was argued that a set of five indices, consisting of private consumption per head, life expectancy at birth, literacy, and indices of civil and political liberties, taken together, are a reasonable approximation for the purpose in hand.

Indices of the quality of life currently in use, such as UNDP's Human Development Index, are cardinal measures. Since indices of civil and political liberties are only ordinal, aggregate measures of social well-being should be required to be ordinal. In this connection, the Borda index suggested itself. In Section 6 the Borda index was put to work on data on what were 46 of the poorest countries in about 1980. Interestingly, of the component indices, the ranking of countries in the sample in terms of life expectancy at birth was found to be the most highly correlated with the countries' Borda ranking. Even more interestingly, the ranking of countries in terms of their GNP per head was found to be almost as highly correlated. There can be little doubt that this finding is an empirical happenstance. But it may not be an uncommon happenstance. If this were so, GNP per head could reasonably continue to be used as a summary measure of social well-being even though it has no theoretical claims to be

[26] As I am wholly inexpert on the matter, I am not offering even a sketch of the kinds of argument that can be advanced to show that the reforms that were urged upon Russia in the early 1990s suffered from a lack of acknowledgement of the role that governance plays in the operation of markets. In an illuminating body of work, Richard Rose (see, for example, Rose, 1999) has been investigating the way social networks there have entered spheres of activity they would not have if citizens were to have enjoyed reliable governance.

one.

It is widely thought that NNP per head measures the economic component of sustainble well-being. In Section 7 it was argued that this belief is false. (In the Appendix the argument is substantiated.) It was shown that NNP, suitably defined, can be used to evaluate economic policies, but that it should not be used in making intertemporal and cross-country comparisons of sustainable well-being. In particular, it was shown that comparisons of sustainable welfare should involve comparisons of wealth. For comparing social well-being in an economy over time, this reduces to checking if net investment is positive or negative or nil. Writings on the welfare economics of NNP have mostly addressed economies pursuing optimal policies, and are thus of limited use. The analysis in Section 7 (and the Appendix below) generalize this substantially by studying environments where governments are capable of engaging only in policy reforms in economies characterized by substantial non-convexities. The analysis pertinent for optimizing governments and convex economies are special limiting cases of the one reported here.

Part III (Sections 8-10) was about policy evaluation. Policy evaluation techniques developed in the 1970s, while formally correct, neglected to consider (1) resource allocation in the wide variety of non-market institutions that prevail throughout the world, and (2) the role the environmental-resource base plays in our lives. It was argued that the evaluation of policy changes can be done effectively only if there is a fair understanding of the way the socio-economic and ecological systems would respond to the changes. The observation is no doubt banal, but all too often decision-makers have neglected to model the combined socio-economic and ecological system before embarking upon new policies or keeping faith in prevailing ones. Examples were provided to show that such neglect has probably meant even greater hardship for precisely those groups of people who are commonly regarded as being particularly deserving of consideration. The examples were also designed to demonstrate how recent advances in our understanding of general resource allocation mechanisms and of environmental and resource economics can be incorporated in a systematic way into what are currently the best-practice policy evaluation techniques.

A.1 The Model

Consider a model economy where the production of goods and services requires labour, manufactured capital, and natural resources. The economy is deterministic. Time is continuous and is denoted by t (≥ 0). Assume that there is an all-purpose, non-deteriorating durable good, whose stock at t is K_t (≥ 0). The good can be either consumed, or spent in increasing the stock of natural resources, or reinvested for its own accumulation. For reasons to be identified in Section A.9, I assume that both population size and the stock of human capital are constant, which means that we may ignore them. The all-purpose good can be produced with its own stock (K), labour (L) and the flow of natural resources (R) as inputs. I write the production function as F(K, L, R). Production of the all-purpose durable good at date t is then $F(K_t, L_t, R_t)$. I take it that F is an increasing and continuously differentiable function of each of its variables. But I do <u>not</u> assume F to be concave. It transpires that we do not need to, given that our interest is in the welfare economics of policy reform.

Let C_t (≥ 0) denote aggregate consumption at t, and E_t (≥ 0) the expenditure on increasing the natural-resource base. Net accumulation of physical capital satisfies the condition:

$$dK_t / dt = F(K_t, L_t, R_t) - C_t - E_t. \qquad (1)$$

It helps to interpret natural resources in broad terms. It enables us to consider a number of issues. We should certainly include in the natural-resource base the multitude of capital assets that provide the many and varied ecosystem services upon which life is based. But we should add to this minerals and fossil fuels. Note too that environmental pollution can be viewed as the reverse side of environmental resources. In some cases the emission of pollutants amounts directly to a degradation of ecosystems (e.g. loss of biomass); in others it amounts to a reduction in environmental quality (e.g. deterioration of air and water quality), which also amounts to degradation of ecosystems. This means that for analytical purposes there is no reason to distinguish resource economics from environmental economics, nor resource management problems from pollution management problems (Dasgupta, 1982). To put it crudely,

[27] This Appendix is based very closely on Dasgupta and Mäler (1999).

"resources" are a "good", while "pollution" (the degrader of resources) is a "bad". So we work with an aggregate stock of natural resources, whose size at t is denoted by S_t (≥ 0). For simplicity of exposition we assume that resource extraction is costless.

Let the natural rate of regeneration of the resource base be $M(S_t)$, where $M(S)$ is a continuously differentiable function.[28] We suppose that the base can also be augmented by expenditure E_t (exploration costs in the case of minerals and fossil fuels, clean-up costs in the case of polluted water, and so forth). Define

$$Z_t = \int_{-\infty}^{t} E_\tau \, d\tau.$$[29]

In certain applications of the model, Z_t would be a measure of the stock of knowledge at t. This interpretation enables us to connect our model with one where there is endogenous technical progress. Let us now re-express equation (2) in the more useable form,

$$dZ_t / dt = E_t. \qquad (3)$$

There are a number of ways in which one can model the process by which the resource base is deliberately augmented. Let $N(E_t, Z_t, S_t)$ denote the rate at which this augmentation occurs, where N is taken to be a continuously differentiable function. It is natural to assume that N is non-decreasing in both E and Z. We therefore assume it to be so.

The dynamics of the resource base can be expressed as:

$$dS_t / dt = M(S_t) - R_t + N(E_t, Z_t, S_t). \qquad (4)$$

We formulate the idea of social welfare in a conventional manner and ignore those many matters which arise when households are heterogeneous. We do this so as to keep the notation tidy. Following the classic articles of Koopmans (1960, 1972), we assume that social well-being at t (≥ 0) is of the "utilitarian" form, $\int_t^\infty U(C_\tau, L_\tau) e^{-\delta(\tau - t)} d\tau$, where U is strictly concave, increasing in C, decreasing in L (at least at large enough values of L), and continuously differentiable in both C and L. δ (> 0), a constant, is the "utility" discount rate. Our analysis does not require that U be concave. We assume it

[28] If the resource in question were minerals or fossil fuels, S_t would denote known reserves at t and we would have $M(S) = 0$ for all S.

[29] Z_0 is part of the data of the economy. Like K_0 and S_0, it is an "initial condition".

nonetheless to be concave for ethical reasons.

A.2 The Analytics of Policy Reform

Let $(C_t, L_t, R_t, E_t, K_t, Z_t, S_t)_0^\infty$ denote an economic programme, from the present (t = 0) to the indefinite future. A theory of economic policy capable of speaking only to optimizing governments would be of very limited interest. For it to be of practical use, a theory should be able to cover economies where governments not only do not optimize, but perhaps cannot even ensure that economic programmes resulting from its policies are intertemporally efficient. Consider then such an economy. To have a problem to discuss, imagine that even though the government does not optimize, it can bring about small changes to the economy by altering its existing, sub-optimal policies in minor ways. The perturbation in question may, for example, consist of small adjustments to the prevailing structure of taxes, or it could be minor alterations to the existing set of property rights, or it could be a public investment, or whatever. We call any such perturbation a policy reform. We proceed to develop the mathematics of policy reforms.

For concreteness, consider an economy facing the technological constraints in equations (1), (3) and (4). In addition, it faces institutional constraints (sometime called transaction and information constraints) which we will formalize presently. The initial capital stocks (K_0, Z_0, S_0) are given and known. By the institutional structure of the economy we will mean market structures, the structure of property-rights, tax rates, and so forth. We take it that the institutional structure is given and known. If in addition we knew the behavioural characteristics of the various agencies in the economy (i.e. those of households, firms, the government, and so on) it would be possible to make a forecast of the economy, by which we mean a forecast of the economic programme $(C_t, L_t, R_t, E_t, K_t, Z_t, S_t)_0^\infty$ that would be expected to unfold. We call this relationship a resource allocation mechanism. So, a resource allocation mechanism is a mapping from initial capital stocks (K_0, Z_0, S_0) into the set of economic programmes $(C_t, L_t, R_t, E_t, K_t, Z_t, S_t)_0^\infty$ satisfying equations (1), (3)-(4).

We now formalise this. Write

$$\Omega_t \equiv (K_t, Z_t, S_t), \text{ and} \tag{5}$$

$$(\xi_\tau)_t^\infty \equiv (C_\tau, L_\tau, R_\tau, E_\tau, K_\tau, Z_\tau, S_\tau)_t^\infty, \text{ for } t \geq 0. \tag{6}$$

Next let $\{t, \Omega_t\}$ denote the set of possible t and Ω_t pairs, and $\{(\xi_\tau)_t^\infty\}$ the set of economic programmes from t to the indefinite future. A resource allocation mechanism, α, can then be expressed as a mapping

$$\alpha: \{t, \Omega_t\} \rightarrow \{(\xi_\tau)_t^\infty\}. \tag{7}$$

α would depend on calender time if knowledge, or population, or terms of trade were to change autonomously over time.[30] If they were not to display any exogenous shift, α would be independent of t. For reasons to be discussed in Section A.8, we will pay particular attention to the case where α is autonomous. So let us assume that α does not depend on calendar time (i.e. it is time-consistent).

It bears re-emphasis that we do <u>not</u> assume α to sustain an optimum economic programme, nor even do we assume that it sustains an efficient programme. The following analysis is valid even if α is riddled with economic distortions and inequities.

To make the dependence of the economic forecast on α explicit, let $(C_t(\alpha), L_t(\alpha), R_t(\alpha), E_t(\alpha), K_t(\alpha), Z_t(\alpha), S_t(\alpha))_0^\infty$ denote the forecast at t = 0. Consider date t (≥ 0). Use (5)-(7) to define

$$V_t(\alpha, \Omega_t) \equiv \int_t^\infty e^{-\delta(\tau-t)} U(C_\tau(\alpha), L_\tau(\alpha)) d\tau. \tag{8}$$

The right-hand-side (RHS) of equation (8) is social welfare at t. In the theory of optimum programming V_t is called the <u>value function</u> at t (Bellman, 1957).[31]

Before putting the concept of resource allocation mechanism to work, it is as well that we discuss examples by way of illustration. Imagine first that all capital assets are private property and that there is a complete set of competitive forward markets capable of sustaining a unique equilibrium. In this case α would be defined in terms of this equilibrium. (If equilibrium were not unique, a selection rule among the multiple equilibria would need to be specified.) Most studies on green accounting (e.g.

---

[30] There are exceptions to this statement in extreme cases, namely, closed economies where production is subject to constant-returns-to-scale, population changes exponentially, technical change is Harrod-neutral, there are no environmental resources, and social well-being is based on classical utilitarianism (Mirrlees, 1967). In such an economy α would be a mapping from the set of capital assets per efficiency unit of labour into the set of economic programmes, where the programmes are expressed in efficiency units of labour.

[31] In all this, we take it that V_t is well defined. The assumption that $\delta > 0$ is crucial for this.

Heal, 1998) are implicitly based on this mechanism.

Of particular interest are situations where some of the assets are not private property. Consider, for example, the class of cases where K and Z are private property, but S is not. It may be that S is a local common-property resource, not open to outsiders. If S is managed efficiently, we are back to the case of a competitive equilibrium allocation, albeit one not entirely supported by market prices, but in part by, say, social norms.

On the other hand, it may be that local institutions are not functioning well (e.g. because social norms are breaking down), in that the marginal private benefits from the use of S exceed the corresponding marginal social benefits. Suppose in addition that decisions bearing on the net accumulation of K and Z are guided by the profit motive. Then these behavioural rules together help determine α. In a similar manner, we could characterize α for the case where S is open-access.

These observations imply that institutional assumptions underlie our notion of resource allocation mechanism. Aspects of the concept of "social capital" (Putnam, 1993) would appear in our framework as part of the defining characteristics of α, as would ideas relating to "social capability" (Adelman and Morris, 1965; Abramovitz, 1986), and "social infrastructure" (Hall and Jones, 1999); other aspects would be reflected as factors in the production functions F and N.[32]

The crucial assumption we now make is that V_t is differentiable in each of the three components of Ω. We apologise for imposing a technical condition on something which is endogenous, but space forbids we explore here the various conditions on an economy's fundamentals (behavioural characteristics of the various agencies and properties of the various production functions and ecological processes; initial set of property rights; and so forth) which would guarantee a differentiable value function.

It is not easy to judge if differentiability of V_t is a strong assumption. What is certainly true is that if α is a differentiable mapping, then V_t is differentiable. We should therefore ask if α is differentiable. This is not easy to answer. An economy's underlying institutional structure is incorporated in α, and there are no obvious limits

[32] The analytics underlying the idea of social capital are explored in Dasgupta (1999).

to the kinds of institutions one can envision. So one looks at what might be termed "canonical" institutions. Analytically, the most well understood are those which support optimum economic programmes. What do we know of the mathematical properties of the corresponding α?

We know that if the production functions are concave and differentiable everywhere, then for optimum economic programmes V_t is differentiable in each of the components of Ω. Interest therefore lies in cases where the production functions are not concave. Now, we know that even if such production functions are differentiable, not only could optimum economic programmes be discontinuous in each of the components of Ω, so could V_t be discontinuous (Skiba, 1978). But at points where V_t is discontinuous, social cost-benefit analysis of policy reforms cannot be conducted solely with the aid of accounting prices: the relevant "consumer surpluses" need to be estimated.[33]

Having noted this, it should be stressed that such discontinuities as we are alluding to are non-generic. So, unless the optimising economy were by fluke at one of the points of discontinuity (they are called "bifurcation points"), V_t would be differentiable within a sufficiently small neighbourhood of the initial capital stocks. The same could be expected to be true for other "canonical" institutions, such as market economies subject to fixed distortions. It would seem, therefore, that the demand that V_t be differentiable would not appear to rule out much of practical significance. The theory we offer here about the role of NNP in social cost-benefit analysis of policy reforms is valid for a considerably more general set of environments than is usual in writings on NNP.

A.3 Local Accounting Prices and their Dynamics

Define,

$$p_t(\alpha) \equiv \partial V_t(\alpha, \Omega_t) / \partial K_t;\ \ q_t(\alpha) \equiv \partial V_t(\alpha, \Omega_t) / \partial Z_t;\ \ \text{and}\ r_t(\alpha) \equiv \partial V_t(\alpha, \Omega_t) / \partial S_t. \qquad (9)$$

We refer to them as local accounting prices. They measure social scarcities of the economy's capital assets along the economic forecast.

How might local accounting prices be estimated? If households are not rationed

[33] The analysis that follows can be extended to cover cases where V_t possesses right- and left-derivatives everywhere, but is not differentiable everywhere.

in any market and externalities are negligible, market prices would be the reasonable estimates. However, when households are rationed or externalities are rampant, estimating local accounting prices involves more complicated work. For example, in the presence of environmental externalities market prices need to be augmented by the external effects (see, for example, Freeman, 1992, for an excellent account of current evaluation techniques). If households are rationed, one has to estimate "willingness-to-pay". And so on. We will presently show that NNP, computed on the basis of local accounting prices, can be used to evaluate short-term policy reform.

What are the dynamics of local accounting prices? To study this, note that the current-value Hamiltonian associated with α can be expressed as

$$H_t = U(C_t, L_t) + p_t(F(K_t, L_t, R_t) - C_t - E_t) + q_tE_t + r_t(M(S_t) - R_t + N(E_t, Z_t, S_t)). \quad (10)$$

Recall equation (8), which we re-write here as:

$$V_t(\alpha, \Omega_t) \equiv \int_t^\infty e^{-\delta(\tau-t)}U(C_\tau, L_\tau)d\tau. \quad (11)$$

V_t is social well-being at t. Differentiating V_t with respect to t we obtain

$$dV_t/dt = \delta V_t - U(C_t, L_t). \quad (12)$$

But $V_t = V_t(\alpha, \Omega_t)$. Using (9), we conclude also that

$$dV_t/dt = p_tdK_t/dt + q_tdZ_t/dt + r_tdS_t/dt + \partial V_t/\partial t. \quad (13)$$

Now combine equations (10), (12)-(13) to obtain

$$H_t = \delta V_t - \partial V_t/\partial t. \quad (14)$$

We can use equations (9) and (14) to conclude that

$$dp_t/dt = -\partial H_t/\partial K_t + \delta p_t;\ dq_t/dt = -\partial H_t/\partial Z_t + \delta q_t;\ \text{and}\ dr_t/dt = -\partial H_t/\partial S_t + \delta r_t. \quad (15)$$

The equations embodied in (15) define the dynamics of local accounting prices. It will be noticed that they are formally the same as the Pontryagin conditions for the evolution of accounting prices in an optimizing economy. Note also that all future effects on the economy of changes in the structure of assets are reflected in local accounting prices. That is why they are useful objects.

As α has been assumed not to depend on calendar time, V_t does not depend on it either. So equation (14) reduces to

$$H_t = \delta V_t.$$

Equation (16) is fundamental in intertemporal welfare economics. It says that the Hamiltonian equals the return on social well-being even in a non-optimizing economy.

A.4 Using NNP to Evaluate Short-Term Policy Reforms

Recall that α is being assumed not to depend on calendar time. Let us now think of a short-term policy reform as a perturbation to α over the short interval $[0, \tau]$. The perturbation is expressed as $\Delta\alpha$. During $[0, \tau]$ the resource allocation mechanism is denoted as $(\alpha + \Delta\alpha)$. From τ onward the economy is assumed to be governed by α again. Note now that if the reform were undertaken, the economic variables during $[0, \tau]$ would be slightly perturbed ($(C_t + \Delta C_t)$ rather than C_t, and so forth). Note too that at τ stocks of capital assets would be slightly different from what they would have been had the reform not been undertaken.[34]

Let the stocks at τ be $(\Omega_\tau + \Delta\Omega_\tau)$ as a consequence of the short-term reform. The change in V_0 arising from the reform can then be expressed as

$$\Delta V_0 = V_0(\alpha+\Delta\alpha, \Omega_0) - V_0(\alpha, \Omega_0)$$
$$= \int_0^\tau e^{-\delta t}[U(C(\alpha+\Delta\alpha), L(\alpha+\Delta\alpha)) - U(C(\alpha), L(\alpha))]dt + e^{-\delta\tau}[V_\tau(\alpha, \Omega_\tau+\Delta\Omega_\tau) - V_\tau(\alpha, \Omega_\tau)] \quad (17)$$

On using equation (9) and the accumulation equations (1), (3) and (4), equation (17) can be expressed as:

$$\Delta V_0 = \tau e^{-\delta\tau}(U_C\Delta C + U_L\Delta L) + e^{-\delta\tau}(V_K\Delta K_\tau + V_Z\Delta Z_\tau + V_S\Delta S_\tau) + \varepsilon(\tau), \quad (18)$$

where $\varepsilon(\tau)$ is an error term with the property that $[\varepsilon(\tau)/\tau] \to 0$ as $\tau \to 0$.[35]

Equation (18) is simple to interpret. A policy reform undertaken during $[0, \tau]$ has two effects on V_0. First, the reform affects consumption and leisure during the period of the reform. Second, it affects the asset structure of the economy at τ, when the reform ends. The right-hand-side (RHS) of equation (A.18) measures the combined effect of the two sets of changes on V_0.

Consider now the perturbation to the asset structure at τ as a consequence of the short-term reform. Observe that

$$\Delta K_\tau = \int_0^\tau \Delta(dK_t/dt)dt = \tau\Delta(dK_t/dt)_{t=0} + \Upsilon(\tau),$$

where $\Upsilon(\tau)$ is an error term with the property that $[\Upsilon(\tau)/\tau] \to 0$ as $\tau \to 0$. Perturbations to Z_τ and S_τ can be estimated in a similar manner. Therefore, equation

---

[34] It is here that we are invoking the assumption that α is a differentiable mapping. Seierstad and Sydsaeter (1987) offers a rigorous account of the reasoning involved here.

[35] U_C and U_L are evaluated at t=0. V_K is the partial derivative of V with respect to K at t=0, and so forth. I have now dropped writing the dependence of the economic forecast on α. This saves on notation.

(18) can be re-written as

$$\Delta V_0/\tau = e^{-\delta\tau}(U_C\Delta C + U_L\Delta L + p_0\Delta(dK_t/dt)_{t=0} + q_0\Delta(dZ_t/dt)_{t=0} + r_0\Delta(dS_t/dt)_{t=0}) + \Theta(\tau), \quad (19)$$

where $\Theta(\tau)$ is an error term with the property that $\Theta(\tau) \to 0$ as $\tau \to 0$. The left-hand-side (LHS) of (19) is the change in social well-being per unit of time during $[0, \tau]$. As we are interested in small perturbations, we let $\tau \to 0$. The LHS of equation (19) then becomes the change in social welfare occasioned by the short-term reform, and the RHS tends in the limit to:

$$U_C\Delta C_0 + U_L\Delta L_0 + p_0\Delta(dK_t/dt)_{t=0} + q_0\Delta(dZ_t/dt)_{t=0} + r_0\Delta(dS_t/dt)_{t=0}. \quad (20)$$

Choose consumption as numeraire and write

$n_0 = -U_L/U_C$; $m_0 = p_0/U_C$; $u_0 = q_0/U_C$; and $v_0 = r_0/U_C$.[36]

On dividing expression (20) by U_C, we obtain

$$\Delta C_0 - n_0\Delta L_0 + m_0\Delta(dK_t/dt)_{t=0} + u_0\Delta(dZ_t/dt)_{t=0} + v_0\Delta(dS_t/dt)_{t=0}. \quad (21)$$

Now use equations (1), (3) and (4) to convert expression (21) into:

$$\Delta C_0 - n_0\Delta L_0 + m_0\Delta(F(K_t,L_t,R_t)-C_t-E_t)_{t=0} + u_0\Delta(E_t)_{t=0} + v_0\Delta(M(S_t)-R_t + N(E_t,Z_t,S_t))_{t=0}. \quad (22)$$

If expression (21), or equivalently (22), is positive, the short-term reform increases social welfare, so it is desirable; if it is negative, the reform decreases social welfare, so it is undesirable. Define

$$_t \equiv U_C C_t + U_L L_t + p_t dK_t/dt + q_t dZ_t/dt + r_t dS_t/dt, \quad (23a)$$

and thereby

$$\__t \equiv C_t - n_t L_t + m_t dK_t/dt + u_t dZ_t/dt + v_t dS_t/dt. \quad (23b)$$

If the right-hand-sides of equations (23a,b) have a familiar ring to them, it is because they represent NNP at t (in utility and consumption numeraires, respectively), measured in local accounting prices. Observe now that expression (21) is the change in NNP at t = 0 occasioned by the short-term policy reform at t = 0. So we have

Proposition 1: A short-term policy reform increases social well-being if and only if it registers an increase in net national product measured in local accounting prices.

Note that NNP as defined here is not NNP as it is usually defined.

[36] Since the economic programme sustained by α is not a first-best, m_0 is typically not equal to 1.

Conventional NNP is the sum of aggregate consumption and net investment in physical capital, with both measured at market prices. Expressions (23a,b) tell us that all components of NNP should be valued at the local accounting prices given in equation (9), and that the accounting value of net investment in the stocks of all durable capital goods (manufactured, natural, human, and knowledge capital) should be included in NNP. The NNP we are studying here is "green NNP".[37]

Note that autonomous changes in α would not affect our result. Being exogenous, such changes would be unaffected by elementary policy reforms, so they are irrelevant for social cost-benefit analysis of policy reform.

The policy reforms we have envisaged here are confined to a short interval. But what if a reform were small but irreversible (e.g. a small permanent change in fuel tax)?

In Section A.9 (Proposition 8) we show how accounting prices can be used to construct indices with which one may evaluate the desirability of such a reform. The indices developed there are linear in quantities. If those indices were not put to use (Johansson and Löfgren, 1996), future changes in consumer surpluses would need to be estimated for the purposes of social cost-benefit analysis. This is because a permanent reform, no matter how small, would have cumulative effects on the size of capital stocks.

How are short-term policy reforms related to optimum planning? Consider an indefinite sequence of such reforms at every t, each of which increases NNP at t, where NNP is computed at the prevailing local accounting prices. We take it that the entire sequence is conducted in a counter-factual manner; that is, as a tat nnement. Such an adjustment process is called a "gradient process" (it is also called the "hill-climbing method"). So far we have not needed to assume convexity of the production possibility set. Now we do. In a well-known paper, Arrow and Hurwicz (1958) proved in the context of a finite-dimensional economy that, provided the set of production possibilities has a sufficiently convex structure, the gradient process converges to the optimum. A corresponding result for our model economy would be harder to prove, given that we are considering infinite-dimensional consumption streams. Our

[37] Dasgupta and Mäler (1991), Mäler (1991), and Dasgupta, Kriström and Mäler (1999) contain a more detailed account of the various components of NNP.

conjecture is that, despite this, a sequence of short-term policy reforms in the form of a suitably defined gradient process would converge to the optimum economic programme if the economy had a strong convex structure.

A.5 The Hamiltonian as Constant-Equivalent Utility

In the previous section we showed that NNP can be used as an index for conducting social cost-benefit analysis of short-term policy reforms. But the theoretical literature on green NNP has been directed toward a quite different end (see especially Weitzman, 1998). It has argued that NNP measures "constant-equivalent consumption". We now look into this interpretation. In order to do that we have to assume that V_t is differentiable everywhere. So we do so.

Continue to assume that $\partial V_t / \partial t = 0$. Since

$\delta[\int_t^\infty e^{-\delta(\tau-t)} d\tau] = 1$, equation (15) can be written as

$$H_t = H_t\{\delta[\int_t^\infty e^{-\delta(\tau-t)} d\tau]\} = \delta[\int_t^\infty e^{-\delta(\tau-t)} H_t d\tau] = \delta V_t,$$

from which we have

$$H_t[\int_t^\infty e^{-\delta(\tau-t)} d\tau] = \int_t^\infty e^{-\delta(\tau-t)} H_t d\tau = V_t \equiv \int_t^\infty e^{-\delta(\tau-t)} U(C_\tau, L_\tau) d\tau. \quad (24)$$

Equation (24) can be summarized as:

Proposition 2: Along any economic programme the Hamiltonian at each date equals the constant-equivalent flow of utility starting from that date.

This result was proved for optimum economic programmes by Weitzman (1976), who restricted his analysis to linear utility functions (specifically that U(C,L) = C). Since in this case the Hamiltonian is NNP, Weitzman interpreted NNP as the constant-equivalent consumption. The interpretation is today in wide usage.

A.6 Social Well-Being and the Concept of Sustainability

World Commission (1987) defined "sustainable development" as an economic programme in which, loosely speaking, the well-being of future generations is not jeopardized. There are a number of possible interpretations of this.[38] Consider the following:

(a) An economic development is sustainable if $dU_t / dt \geq 0$, where $U_0 \geq \lim U_t$ as t

[38] See Pezzey (1992) for a thorough treatment. It should be noted that to ask if economic development is sustainable is different from asking if a given level of consumption is sustainable. See below in the text.

$\rightarrow$ -0.

(b) An economic development is sustainable if $dU_t / dt \geq 0$.

(c) An economic development is sustainable if $dV_t / dt \geq 0$,

where $V_t(\alpha, \Omega_t) \equiv \int_t^\infty e^{-\delta(\tau - t)} U(C_\tau, L_\tau) d\tau$.

It is clear that (a) lacks ethical foundation. For example, it may be desirable to reduce U in the short run in order to accumulate assets in order that the flow of U is still higher in the future. In this sense (b) offers greater flexibility in ethical reasoning: it permits initial sacrifices in the current standard of living, U (a burden assumed by the generation engaged in the reasoning), but requires that no future generation should have to experience a decline in their standard of living.

Consider the resource allocation mechanism α. The mechanism allows one to make an economic forecast. Suppose (b) were to be adopted as the definition of sustainable development. Now

$$dU_t / dt = U_C dC_t / dt + U_L dL_t / dt. \qquad (25)$$

From equation (25) we may conclude with:

Proposition 3: If sustainable development is taken to mean that, starting from now, utility must never decline, then an economic programme corresponds to sustainable development if, and only if, the value of changes in the flow of consumption services is always non-negative.

A.7 Comparisons of Social Welfare Across Time

In contrast to (b), the focus of (c) as a notion of sustainable development is social well-being, V. The criterion permits the first generation to make initial sacrifices in V (relative to the past), but requires that social well-being should never decline in the future. Note that, while (b) implies (c), (c) does not imply (b).[39] In short, (c) is more general. In what follows, we adopt (c) as our notion of sustainable development and develop criteria for judging if a given economic programme represents sustainable development.

Continue to assume that $\partial V_t / \partial t = 0$. Differentiating both sides of equation (15) with respect to time, we have

[39] For an arbitrary α this is a trivial matter to confirm. Interestingly, Asheim (1994) has identified cases where even an optimum economic programme may satisfy (c), while violating (b).

$$dH_t / dt = \delta dV_t / dt.$$

Use (23b) to define

$$I_t^K \equiv p_t dK_t / dt;\ I_t^Z \equiv q_t dZ_t / dt;\ \text{and}\ I_t^S \equiv r_t dS_t / dt, \tag{27}$$

which are net investments in the three types of capital assets, respectively, expressed in utility numeraire. We may then define aggregate net investment as,

$$I_t = I_t^K + I_t^Z + I_t^S.^{40} \tag{28}$$

It follows from equations (10), (13) and (26)-(28) that

$$U_C dC / dt + U_L dL / dt + dI_t / dt = \delta I_t. \tag{29}$$

Equation (29) enables us to obtain two alternative indicators of sustainable development. The first can be obtained from the RHS of equation (29). For it implies

Proposition 4: An economic programme increases social well-being over time if, and only if, along the programme net investment in the economy's capital assets is always positive.[41]

The result has intuitive appeal. It says that social welfare is higher today than it was yesterday if the economy is wealthier today. Here, an economy's "wealth" is interpreted as the accounting value of all its capital assets, and wealth comparisons are made at constant prices. In a famous article Samuelson (1961) argued in connection with national income accounting that welfare comparisons should deal with "wealth-like" entities. Proposition 4 formalizes that insight.

Note, however, that what we have obtained is an equivalence result: Proposition 4 cannot on its own tell us if sustainable development is feasible. Whether

---

[40] Note that the summation in equation (28) does not imply any assumptions regarding substitution possibilities among the three kinds of capital assets. Whatever substitution possibilities there may be would be reflected in the local accounting prices.

[41] This result, shown to be a property of optimum economic programmes, originated in Solow (1974, 1992) and Hartwick (1977), who determined the investment rule that would sustain the maximum constant utility stream, and in Dasgupta and Heal (1979, ch. 10), who showed in the context of a model economy consisting of manufactured capital and an exhaustible resource that, along an optimum economic programme social well-being is an increasing function of time if $\delta = 0$ and that this requires net savings to be positive. Pearce, Hamilton and Atkinson (1996) suggested the use of the rule we have obtained in the text for practical purposes, but offered no proof that the suggestion is valid. Serageldin (1995) has reported empirical work done at the World Bank on the use of the rule. See also World Bank (1996).

the economy is capable of growing wealthier indefinitely depends, among other things, on the extent to which different assets are substitutable in production.[42]

An equivalent way of characterising sustainable development is to use the LHS of equation (29). We state the result as:

Proposition 5: Social welfare increases (decreases) over a short interval of time if, and only if, during the interval the value of net changes in the flow of consumption services plus the change in the value of net aggregate investment is positive (negative).

For making intertemporal welfare comparisons it is customary to compare NNP over time at constant prices. Proposition 5 says that this is not a correct procedure unless the economy is stationary (i.e. $dp_t/dt = dq_t/dt = dr_t/dt = 0$). We conclude that intertemporal NNP comparisons are far less informative about changes in social welfare over time than is commonly believed. Indeed, they would be highly misleading indicators if relative prices were changing significantly. Note that this is consistent with Proposition 1, which says that NNP provides a valid measure of the impact on social well-being of short-term policy reforms.

A.8 Comparisons of Social Welfare Across Space

In both popular and academic writings cross-country comparisons of GNP per head are today a commonplace method for comparing well-being across countries. The analysis in the previous section suggests not only that this practice is wrong, but also that replacing GNP by NNP would not rescue matters. So the question is what index should be used instead? We look into this.

It is simplest to consider a continuum of closed economies, parametrized by x (a scalar).[43] We may interpret differences among economies in terms of differences in initial endowments, or behavioural characteristics, or the resource allocation mechanisms guiding them. But in order to make meaningful comparisons of social well-being, we must be able to ascribe the same value-function to all countries, that is,

[42] For an account of this, see Dasgupta and Heal (1979, ch. 7). The problem is deeper than was recognized in that work, since substitutability involves substitutability not merely in production, but also in consumption. On this see Dasgupta, Levin, Lubchenco and Mäler (1999).

[43] I assume a continuum of economies in order to make use of the calculus. It simplifies the computations. The analysis that follows can be easily adapted for the case where there is a discrete number of economies.

the same utility function U(.) and the same δ.

Consider a date when the cross-country comparisons are to be made. To keep the notation simple, we drop the time subscript. Let H_x be the Hamiltonian in country x and V_x the value function there. Recall equation (15). In the present case it reads as $H_x = \delta V_x$. An argument identical to the one establishing equation (29) then yields

$$\delta[p_x dK_x/dx + q_x dZ_x/dx + r_x dS_x/dx + \partial V_x/\partial x] = U_C dC_x/dx + U_L dL_x/dx + dI_x/dx + \partial H_x/\partial x, \quad (30)$$

where I_x is net aggregate investment in country x.

For tractability, the interesting special case to consider is $\partial V_x/\partial x = \partial H_x/\partial x = 0$.[44] From the LHS of equation (30) we conclude:

Proposition 6: Social well-being in a country is higher (lower) than in any of its immediate neighbours if in the aggregate it is wealthier (less wealthy).

Proposition 6 formalizes the insight in Samuelson (1961) that in making welfare comparisons across countries, one should compare their wealths. It corresponds to Proposition 4.

An equivalent indicator for making welfare comparisons can be obtained from the RHS of equation (30):

Proposition 7: Social well-being in a country is higher (lower) than in any of its immediate neighbours if the value of the difference in the flow of consumption services between them plus the difference in the value of aggregate net investment between them is positive (negative).

Notice that the recommendation in Proposition 7 (which corresponds to Proposition 5) would not amount to NNP comparisons across countries unless local accounting prices were the same (i.e. $dp_x/dx = dq_x/dx = dr_x/dx = 0$). I conclude that cross-country comparisons of NNP tell us nothing about differences in social well-being excepting under empirically uninteresting circumstances.

Equation (30) is exact, but the pair of (linear) indicators we have obtained in Propositions 6 and 7 serve their purpose accurately only when $\partial V_x/\partial x = 0$. I believe this to be a strong condition. If, as we suspect is the case, $\partial V_x/\partial x$ is not even

[44] The condition requires that the same resource allocation mechanism prevails in all countries. The condition is strong.

approximately zero, there are no linear indices to be had for making cross-country welfare comparisons.

A.9 Evaluation of Permanent Policy Change

The technique we have developed for making cross-country comparisons of social well-being can also be used for evaluating the desirability of a permanent policy reform, or of a permanent change in some parameter of the economy. In keeping with the notation introduced in section 4, let α be this parameter (e.g. the given resource allocation mechanism). Then, retracing the arguments there, we may write equation (16) as

$$H_t(\alpha) = {}^{\delta}V_t(\alpha). \qquad (31)$$

Using equations (27)-(29), we obtain

$${}^{\delta}dV_t(\alpha)/d\alpha = dH_t(\alpha)/d\alpha = U_C dC_t(\alpha)/d\alpha + U_L dL_t(\alpha)/d\alpha + dI_t(\alpha)/d\alpha. \qquad (32)$$

From equation (32) we have

Proposition 8: If the value of the changes in consumption services plus the change in the value of net investment occasioned by a permanent change in a parameter characterising an economy is positive (negative), social well-being increases (decreases).

A.10 Technological Change and Growth Accounting

How should NNP be computed in the presence of technical change? Note first that resource augmentation, N, in equation (4) could itself be regarded as a form of technical progress. This said, it must also be granted that the growth and decay of knowledge involve wider considerations. For example, it has been customary in the economics literature to regard technical progress as shifts in production functions. In what follows I explore this route by introducing technical progress in the production of the final good in the model of Section A.3.

We need to extend our notation. Denote by E_{1t} and E_{2t} expenditures on resource augmentation and on generalized research and development (R & D), respectively. Now define Z_{1t} and Z_{2t} by the equations

$$dZ_{1t}/dt = E_{1t}, \qquad (33)$$

and $dZ_{2t}/dt = E_{2t}$. (34)

Z_1 and Z_2 can be thought of as two types of knowledge. Denote the resource augmentation function as $N(E_1, Z_1, S)$ and imagine that output of the produced consumption good at t can be expressed as

$$Y_t = e^{\lambda t}Q(Z_{2t})F(K_t, L_t, R_t), \quad (35)$$

where $\lambda \geq 0$ and $Q'(Z_2) \geq 0$. Technical progress in the production of the final good appears here as the term $e^{\lambda t}Q(Z_{2t})$. It combines exogenous factors (λ) with endogenous ones (Z_2).

Let consumption be the numeraire, u_1 and u_2 the local accounting prices of Z_1 and Z_2, respectively, and let the remaining local accounting prices be denoted as in Section A.5. Retracing the arguments leading to (23b), it is a simple matter to conclude that NNP reads as:

$$\__t = C_t - n_tL_t + m_tdK_t/dt + u_{1t}dZ_{1t}/dt + u_{2t}dZ_{2t}/dt + v_tdS_t/dt. \quad (36)$$

Similarly one can confirm that the discussion in Section A.5 on the evaluation of short-term policy reform remains unchanged in the presence of technical change.

The question remains: what factors contribute to changes in GNP over time? To see what the answer could be, consider that GNP in our model economy is given by (35). Differentiating both sides of equation (35) with respect to t, re-arranging terms, and dropping the time subscript from variables for the sake of notational simplicity, we obtain the growth accounting identity as

$$(dY/dt)/Y \equiv \lambda + (Q'(Z_2)dZ_2/dt)/Q(Z_2) + (F_KdK/dt)/F + (F_LdL/dt)/F + (F_RdR/dt)]/F. \quad (37)$$

The sum of the first two terms on the RHS of equation (37) measures the percentage rate of change in "total factor productivity", while the remaining terms together represent the contributions of changes in the "factors of production" to the percentage rate of change in GNP. Since λ is an exogenous factor, it is unexplained within the model. For this reason it is called the "residual". When it is not zero, λ could well be the most important determinant of $\partial V_t/\partial t$.

In a famous article, Solow (1957) used a reduced-form of the production function in (35) to estimate the contribution of changes in the factors of production to growth of non-farm GNP per "man-hour" in the US economy over the period 1909-

1949, and discovered that it was a mere 12 percent of the average annual rate of growth.[45] In other words, 88 percent of the growth was attributable to the residual. (Solow's estimate of λ was 1.5 percent per year.) A significant empirical literature since then has shown that when K is better measured (e.g. by accounting for changes in the utilization of capacity and changes in what is embodied in capital; see footnote 28 below) and when account is taken of human-capital formation, the residual is small for the non-farm sector in the US economy.[46]

This is congenial to intuition. We should doubt if it is prudent to postulate everlasting increases in total factor productivity, let alone in per capita output. To do so would be to place an enormous burden of proof on an experience which is not much more than a few hundred years old. Extrapolation into the past is a sobering exercise: over the long haul of time (say, a few thousand years), the residual has been not much more than zero.

It is in any case hard to believe that serendipity, unbacked by R&D effort and investment in physical capital (learning by doing), can be a continual source of productivity growth. A positive value of λ would imply that the economy is guaranteed a "free lunch" forever. To be sure, such an assumption would guarantee that growth in aggregate consumption was sustainable. In fact, that would be its attraction: it would enable us to assume away problems of environmental and resource scarcities. But there are no theoretical or empirical grounds for presuming that it is a reasonable assumption. At this point in our understanding of the process by which discoveries are made, it makes greater sense to set $\lambda = 0$ in (35), (which would imply that $\partial V_t / \partial t = 0$).[47] This thought is reinforced by the observation that most

[45] Solow assumed in particular that $Q'(Z_2) = 0$.

[46] Jorgenson (1995) contains a masterly account of this complex literature.

[47] Lau (1996) reports on a series of studies that have specified the aggregate production function to be of the form $Y_t = F(A_t K_t^{a} H_t^{(1-a)}, L_t)$, where K is physical capital, H is human capital, A is the augmentation factor of the composite capital, L is the number of labour-hours, and $0 < a < 1$. The studies have uncovered that, since the end of the Second World-War, the contribution of technical progress (i.e. the percentage rate of change in A_t) to growth in Y_t in today's newly industrialized countries has been negligible. He also reports that, if new knowledge is taken to be embodied in new capital-equipment, the contribution of growth in the value of A_t to growth in Y_t among western industrialized economies has been a mere 10 percent, that of growth in physical capital some 75 percent, while the contributions of growth in human capital and labour-hours have each been some 7 percent. Lau also notes that the

environmental resources go unrecorded in growth accounting. The implication is obvious: when we regress growth in GNP on growth in inputs which exclude the use of environmental resources, we obtain too high an estimate of λ if in fact the use of such resources has been growing. In adopting this position, I am not suggesting that there is no such thing as technical change; what I am suggesting is that of the first two terms on the right-hand-side of equation (37), it is the second term which is significant. It denotes the contribution of technical change to productivity growth.

Productivity growth in equation (37) is productivity growth in GNP. It has often been suggested that we should instead be interested in productivity growth in NNP, as defined in equation (36). For example, in their important early work on Indonesia, Repetto et al. (1989) showed that if one were to include deforestation, soil erosion, and the depreciation of oil reserves in the country's national accounts, Indonesia's rate of growth in NNP during the 1980s would be half the estimated growth rate of her GNP. And there are other environmental and natural resources that Repetto et al. did not consider.

In Section A.6 it was shown that NNP comparisons across time tell us nothing about changes in social well-being unless an economy is in a steady state. It was also shown that we should ask instead if, in the aggregate, net investment is positive. It is possible for an economy's GNP (per head) to increase over a period of time even while, in the aggregate, net investment (per head) is negative. I know of no evidence that in recent years this has not been experienced in a number of countries.[48]

A.11 Commentary

Green NNP has widely been interpreted as constant-equivalent consumption. In Section A.5 it was shown that, excepting for the uninteresting case where U is linear in consumption (or else homogeneous of degree less than one), this interpretation is simply false. What is true is that the Hamiltonian which equals constant-equivalent utility (Proposition 2). However, since the Hamiltonian is typically a non-linear function of consumption and leisure, it is of little practical use.

---

studies are silent on whether technical progress in Western industrialized economies has been exogenous or the fruit of expenditures on research and development.

[48] Serageldin (1995) contains a report on the beginnings of this research programme.

In developing the concept of NNP I have made use of a series of models of increasing generality. However, of necessity even the most general of the models had important features missing. I comment on a few of them. Readers can easily fill in the details.

(1) Problems associated with intragenerational distribution have been ignored. However, it is theoretically a simple matter to include them. The way to do it would be to enlarge the set of commodities so as to distinguish a good consumed or supplied by one person from that same good consumed or supplied by another person. This means, for example, that a piece of clothing worn by a poor person should be regarded as a different commodity from that same type of clothing worn by a rich person. Such commodities are called "named goods" (Hahn, 1971). Accounting prices of named goods would typically depend on the names attached to them. With this re-interpretation of goods and services, the results we have obtained continue to hold.[49]

(2) Environmental externalities can be incorporated by a device identical to (1) above. To describe who is affected, in which manner, and by whose actions involves the use of named goods and services. It follows that accounting prices would be "named", so as to distinguish private costs from social costs and private benefits from social benefits. Indeed, Pigouvian taxes and subsidies on externalities can be computed on the basis of named accounting prices (Dasgupta and Heal, 1979, ch. 3; Mäler, 1991; Freeman, 1992).

(3) Uncertainty has been avoided here. Assume then that social well-being at date t=0 is the expected value of the present discounted flow of utility. The natural move would be to make use of the idea of contingent goods, and therefore of contingent accounting prices. Our analysis would then go through.

(4) The discussion has been restricted to closed economies. However, the analysis can be extended to an economy that trades with the rest of the world. Dasgupta, Kriström and Mäler (1995) and Sefton and Weale (1996) contain an account of this.

---

[49] I am assuming in this example that income or wealth mal-distribution is the cause of concern. Dasgupta, Marglin and Sen (1972) suggested the use of income distributional weights as a rough-and-ready way to capture such concern. The Bergson social welfare function was designed precisely to incorporate these considerations.

(5) Human capital has been absent from the discussion. Analytically it is not difficult to include it. Human capital can be thought of as another form of capital. So net investment in it would be included in NNP (see Dasgupta, Kriström and Mäler, 1995, for a formulation). However, unlike physical capital, human capital is non-transferable. So they should be regarded as named goods.

(6) The models studied here have not included demographic change. It is customary in growth accounting to regard changes in population over time as exogenously given. However, in many societies parents regard children as both an end in themselves and a means to other things (e.g. income security). So population needs to be regarded as a stock whose movements over time are, at least in part, endogenously determined. The problem is that our current understanding of the determinants of fertility behaviour is weak. Moreover, serious problems arise when one comes to construct intergenerational welfare economics in such a world. There is no received theory. Population ethics is an underdeveloped field of inquiry. For the moment it would seem reasonable to conduct such analyses as we have conducted conditional on specified demographic movements. This has been our approach here.[50]

Finally, it is as well to re-stress that this Appendix been about conceptual matters only. The findings here imply that the estimation of accounting prices should now be a priority. This said, it must be acknowledged that estimating the accounting prices of certain categories of resources will prove to be impossible. So no single index could suffice. But this means that tradeoffs would have to be made explicitly (e.g. how much biodiversity should be permitted to be destroyed for the sake of so many dollars of aggregate income?). These are hard choices, even tragic choices. But I believe they are unavoidable.

[50] See Dasgupta (1998) for a discussion of some of the more transparent problems that arise when one thinks about the concept of optimum population.

Table 1

Living Standards' Indicators in 1980

	(Y)	C	E	L	R_1	R_2
Bangladesh	(540)	491	48	26	4	4
Benin	(534)	427	47	28	7	7
Bolivia	(1529)	1147	50	63	3	5
Botswana	(1477)	827	55	35	3	2
Burundi	(333)	393	46	25	6	7
C.A.R.	(487)	536	47	33	7	7
Chad	(353)	339	42	15	6	6
China	(1619)	955	67	69	6	6
Ecuador	(2607)	1642	63	81	3	5
Egypt	(995)	657	58	44	5	5
Ethiopia	(325)	260	44	15	7	7
Haiti	(696)	633	52	23	6	7
Honduras	(1075)	720	60	60	3	6
India	(614)	423	54	36	3	2
Indonesia	(1063)	606	53	62	5	5
Jordan	(1885)	1372	62	70	6	6
Kenya	(662)	430	55	47	5	5
Korea	(2369)	1486	67	93	5	5
Lesotho	(694)	1106	52	52	4	5
Liberia	(680)	374	52	25	4	6
Madagascar	(589)	437	51	50	5	5
Malawi	(417)	334	44	25	6	6
Mali	(356)	288	44	10	7	7
Mauritania	(576)	271	43	17	6	6
Mauritius	(1484)	1042	65	85	2	4
Morocco	(1200)	803	57	28	4	3
Nepal	(490)	456	45	19	6	5
Niger	(441)	309	42	10	6	7
Nigeria	(824)	511	48	34	3	5
Pakistan	(990)	821	49	24	5	6
Paraguay	(1979)	1464	66	84	5	5
Philippines	(1551)	1039	61	75	5	5
Rwanda	(379)	322	45	50	5	6
Senegal	(744)	655	45	10	3	4
Sierra L.	(512)	394	38	15	5	6
Somalia	(415)	324	44	60	7	7
Sri Lanka	(1200)	509	68	85	3	2
Sudan	(652)	554	46	32	5	5
Swaziland	(1079)	550	51	65	6	5
Tanzania	(353)	275	50	79	6	6
Thailand	(1694)	1117	62	86	4	6
Tunisia	(1845)	1107	60	62	6	5
Uganda	(257)	252	46	52	7	7
Zaire	(224)	168	49	55	6	7
Zambia	(716)	387	50	44	5	5
Zimbabwe	(930)	586	55	69	5	5

Key:

Y - per capita GNP (international dollars)
C - per capita private consumption (international dollars)
E - life expectancy at birth (years)
L - adult literacy rate (%)
R_1 - index of political rights
R_2 - index of civil rights

Abbreviations: C.A.R. (Central African Republic) and Sierra L. (Sierra Leone).

Source: World Bank (1982) and Dasgupta and Weale (1992)

Table 2
Rankings of Living Standards Data for 1980

	BORDA	C	E	L	R_1	R_2	(Y)	RANK
Mali	1	6	5	1	1	1		7
Ethiopia	1	3	5	4	1	1		3
Niger	3	7	2	1	7	1		11
Mauritania	4	4	4	7	7	11		17
Chad	5	11	2	4	7	11		6
Malawi	6	10	5	10	7	11		10
Uganda	6	2	12	27	1	1		2
Burundi	8	14	12	11	7	1		4
Somalia	9	9	5	30	1	1		9
Benin	10	17	15	15	1	1		15
Sierra L.	11	15	1	4	20	11		14
Zaire	12	1	19	29	7	1		1
C.A.R.	13	24	15	18	1	1		12
Nepal	14	20	9	8	7	23		13
Haiti	15	29	26	9	7	1		24
Rwanda	16	8	9	25	20	11		8
Tanzania	17	5	21	40	7	11		5
Liberia	18	12	26	11	33	11		22
Pakistan	19	34	19	10	20	11		29
Sudan	20	26	12	17	20	23		20
Zambia	21	13	21	22	20	23		25
Madagascar	22	19	24	25	20	23		18
Swaziland	23	25	24	35	7	23		33
Kenya	24	18	31	24	20	23		21
Senegal	25	30	9	1	38	40		26
Nigeria	26	23	17	19	38	23		27
Bangladesh	27	21	17	14	33	40		16
Egypt	28	31	35	22	20	23		30
Indonesia	29	28	29	32	20	23		31
China	30	36	44	36	7	11		40
Zimbabwe	31	27	31	36	20	23		28
Jordan	32	43	39	38	7	11		43
Tunisia	32	40	36	32	7	23		42
Honduras	34	32	36	30	38	11		32
India	35	16	29	21	38	44		19
Lesotho	35	39	26	27	33	23		23
Philippines	37	37	38	39	20	23		39
Bolivia	38	42	21	34	38	23		38
Morocco	38	33	34	15	33	43		35
Botswana	40	35	31	20	38	44		36
Thailand	41	41	39	45	33	11		41
Paraguay	42	44	43	42	20	23		43
Korea	43	45	44	46	20	23		45
Ecuador	44	46	41	41	38	23		46
Sri Lanka	45	22	46	43	38	44		34
Mauritius	46	38	42	43	46	40		36

Key:

BORDA RANK - ranking using Borda Rule
C - per capita private consumption (international dollars)
E - life expectancy at birth (years)
L - adult literacy rate (%)
R_1- index of political rights
R_2- index of civil rights
Y - per capita GNP (international dollars)

Abbreviations: C.A.R. (Central African Republic), and Sierra L. (Sierra Leone).

Table 3

(Spearman) Correlation Matrix of Living Standard Rankings

C	0.84					
E	0.88	0.75				
L	0.72	0.54	0.79			
R_1	0.76	0.51	0.48	0.28		
R_2	0.75	0.50	0.50	0.30	0.76	
Y	0.87	0.91	0.83	0.61	0.55	0.57
	Borda	C	E	L	R_1	R_2

References

Abramovitz, M. (1986), "Catching Up, Forging Ahead, and Falling Behind", Journal of Economic History, 56, 385-406.

Adelman, I. and C.T. Morris (1965), "A Factor Analysis of the Interrelationship between Social and Political Variables and per Capita Gross National Product", Quarterly Journal of Economics, 79, 555-578.

Ahmad, E. and N. Stern (1990), The Theory and Practice of Tax Reform for Developing Countries (Cambridge: Cambridge University Press).

Aronsson, T., P.-O. Johansson and K.-G. Löfgren (1997), Welfare Measurement, Sustainability and Green National Accounting (Cheltenham, UK: Edward Elgar).

Aronsson, T. and K.-G. Löfgren (1998), "Green Accounting: What Do We Know and What Do We Need to Know?", in T. Tietenberg and H. Folmer, eds., The International Yearbook of Environmental and Resource Economics 1998/1999 (Cheltenham, UK: Edward Elgar).

Arrow, K.J. (1963, [1951]): Social Choice and Individual Values, 2nd Ed. (New York: John Wiley).

Arrow, K.J. and L. Hurwicz (1958), "Gradient Method for Concave Programming, III: Further Global Results and Applications to Resource Allocation", in K.J. Arrow, L. Hurwicz and H. Uzawa eds., Studies in Linear and Non-Linear Programming (Stanford, CA: Stanford University Press).

Asheim, G. (1994), "Net National Product as an Indicator of Sustainability", Scandinavian Journal of Economics, 96, 257-65.

Asheim, G. (1997), "Adjusting Green NNP to Measure Sustainability", Scandinavian Journal of Economics, 99, 355-370.

Bellman, R. (1957), Dynamic Programming (Oxford: Oxford University Press).

Chichilnisky, G. and G.M. Heal (1998), "Economic Returns from the Biosphere", Nature, 391, 629-630.

Costanza R.R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, M. van den Belt (1997), "The Value of the World's Ecosystem Services and Natural Capital", Nature, 387, 253-260.

Daily, G., T. Soederqvist, S. Aniyar, K. Arrow, P. Dasgupta, P. Ehrlich, C. Folke, A.-M. Jansson, B.-O. Jansson, N. Kautsky, S. Levin, J. Lubchenco, K.-G. Mäler, D. Simpson, D. Starrett, D. Tilman, and B. Walker (1999), "The Value of Nature and the Nature of Value", Processed. Beijer International Institute of Ecological Economics, Stockholm.

Dasgupta, P. (1982), The Control of Resources (Cambridge, MA: Harvard University Press).

Dasgupta, P. (1990), "The Environment as a Commodity", Oxford Review of Economic Policy, 6, 51-67.

Dasgupta, P. (1993), An Inquiry into Well-Being and Destitution (Oxford: Clarendon Press).

Dasgupta, P. (1998), "Population, Consumption and Resources: Ethical Issues", Ecological Economics, 24(2), 139-152.

Dasgupta, P. (1999), "Economic Progress and the Idea of Social Capital", in P. Dasgupta and I. Serageldin, eds., Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).

Dasgupta P. and G.M. Heal (1979), Economic Theory and Exhaustible Resources (Cambridge: Cambridge University Press).

Dasgupta, P., B. Kriström and K.-G. Mäler (1995), "Current Issues in Resource Accounting", in P.O. Johansson, B. Kriström and K.-G. Mäler, eds., Current Issues in Environmental Economics (Manchester: Manchester University Press).

Dasgupta, P., B. Kriström and K.-G. Mäler (1999), "Decentralization and the Evaluation of Policy Reform in Dynamic Economies", Processed, Beijer International Institute of Ecological Economics, Stockholm.

Dasgupta, P., S. Levin and J. Lubchenco (1999), "Economic Pathways to Ecological Sustainability: Challenges for the New Millennium", Department of Evolutionary Biology, Princeton University. Processed. Forthcoming, BioScience, 2000.

Dasgupta, P., S. Levin, J. Lubchenco and K.-G. Mäler (1999), "On Eco-System Services and Economic Substitutability", Processed, Beijer International Institute of Ecological Economics, Stockholm.

Dasgupta, P. and K.-G. Mäler (1995), "Poverty, Institutions, and the Environmental Resource-Base," in J. Behrman and T.N. Srinivasan, eds., Handbook of Development Economics, Vol. IIIA (Amsterdam: North Holland).

Dasgupta, P. and K.-G. Mäler (1999), "Net National Product and Social Well-

Being", Beijer International Institute of Ecological Economics. Processed. Forthcoming, Environment and Development Economics, 2000.

Dasgupta, P., S. Marglin and A. Sen (1972), Guidelines for Project Evaluation (New York: United Nations).

Dasgupta, P. and I. Serageldin, eds. (1999), Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).

Dasgupta, P. and M. Weale (1992), "On Measuring the Quality of Life", World Development, 20, 119-131.

Dreze, J. and N. Stern (1990), "Policy Reform, Shadow Prices, and Market Prices", Journal of Public Economics, 42, 1-45.

Easterlin, R. (1974), "Does Economic Growth Improve the Human Lot? Some Empirical Evidence", in P.A. David and M. Reder, eds., Nations and Households in Economic Growth: Essays in Honor of Moses Abramowitz (New York: Academic Press).

Fine, B. and K. Fine (1974): "Social Choice and Individual Rankings, II", Review of Economic Studies, 44, 459-475.

Freeman III, A.M. (1992), The Measurement of Environmental and Resource Values (Washington, D.C.: Resources for the Future).

Frey, B. and A. Stutzer (1999), "Measuring Preferences by Subjective Well-Being", Journal of Institutional and Theoretical Economics, 155.

Goodman, L.A. and H. Markowitz (1952): "Social Welfare Functions based on Individual Rankings", American Journal of Sociology, 58.

Graff, J. de V. (1962), Theoretical Welfare Economics (Cambridge: Cambridge University Press).

Hahn, F.H. (1971), "Equilibrium with Transactions Costs", Econometrica, 39(3), 417-440.

Hall, R.E. and C.I. Jones (1999), "Why Do Some Countries Produce So Much More Output Per Worker Than Others?", Quarterly Journal of Economics, 114, 83-116.

Harsanyi, J.C. (1955), "Cardinal Welfare, Individualistic Ethics and Interpersonal Comparisons of Utility", Journal of Political Economy, 63.

Hartwick, J. (1977), "Intergenerational Equity and the Investing of Rents from Exhaustible Resources", American Economic Review, 66, 972-974.

Hartwick, J. (1990), "Natural Resources, National Accounting, and Economic Depreciation", Journal of Public Economics, 43, 291-304.

Hartwick, J. (1994), "National Wealth and Net National Product", Scandinavian Journal of Economics, 96, 253-56.

Heal, G.M. (1998), Valuing the Future: Economic Theory and Sustainability, (New York: Columbia University Press).

Hicks, J.R. (1940), "The Valuation of Social Income", Economica, 7, 105-124.

Johansson, P.-O. and K.-G. Löfgren (1996), "On the Interpretation of 'Green' NNP Measures as Cost-Benefit Rules", Environmental and Resource Economics, 7, 243-250.

Jorgenson, D. (1995), Productivity: Postwar U.S. Economic Growth (Cambridge, MA: MIT Press).

Koopmans, T.C. (1960), "Stationary Ordinal Utility and Impatience", Econometrica, 28, 287-309.

Koopmans, T.C. (1972), "Representation of Preference Orderings over Time", in C.B. McGuire and R. Radner, eds., Decision and Organization (Amsterdam: North Holland).

Lau, L. (1996), "The Sources of Long-Term Economic Growth: Observations from the Experiences of Developed and Developing Countries", in R. Landau, T. Taylor and G. Wright, eds., The Mosaic of Economic Growth (Stanford, CA: Stanford University Press).

Lindahl, E (1934), "The Concept of Income", in G. Bagge, ed., Economic Essays in Honor of Gustaf Cassel, (London: George Allen and Unwin).

Little, I.M.D. and J.A. Mirrlees (1974), Project Appraisal and Planning for Developing Countries (London: Heinemann).

Mäler K.-G. (1974), Environmental Economics: A Theoretical Enquiry (Baltimore, MD: Johns Hopkins University Press).

Marshall, T.H. (1964), Class, Citizenship and Social Development (Garden City, NY: Doubleday & Co.).

Marshall, T.H. (1981), The Right to Welfare and Other Essays (New York: Free Press).

McKean, M. (1992), "Success on the Commons: A Comparative Examination of Institutions for Common Property Resource Management", Journal of Theoretical Politics, 4, 256-68.

Meade, J.E. (1955), Trade and Welfare (Oxford: Oxford University Press).

Mirrlees, J.A. (1967), "Optimum Growth When the Technology is Changing", Review of Economic Studies, 34 (Symposium Issue), 95-124.

Mitchell, R.C. and R.T. Carson (1989), Using Surveys to Value Public Goods: The Contingent Valuation Method (Washington, D.C.: Resources for the Future).

Nozick, R. (1974), Anarchy, State and Utopia (New York: Basic Books).

Ostrom, E. (1996), "Incentives, Rules of the Game, and Development", Proceedings of the Annual World Bank Conference on Development Economics, 1995 (Supplement to the World Bank Economic Review and the World Bank Research Observer), 207-34.

Ostrom, E. and R. Gardner (1993), "Coping with Asymmetries in the Commons: Self-Governing Irrigations Can Work", Journal of Economic Perspectives, 7, 93-112.

Oswald, A.J. (1997), "Happiness and Economic Performance", Economic Journal, 107, 1815-1831.

Pearce, D., K. Hamilton and G. Atkinson (1996), "Measuring Sustainable Development: Progress on Indicators", Environment and Development Economics, 1, 85-101.

Pezzey, J. (1992), "Sustainable Development Concepts: An Economic Analysis", World Bank Environment Paper No. 2, World Bank, Washington, D.C.

Putnam, H. (1989), "Objectivity and the Science/Ethics Distinction", WIDER Working Paper 70 (Helsinki: World Institute for Development Economics Research).

Putnam, R.D., with R. Leonardi and R.Y. Nanetti (1993), Making Democracy Work: Civic Traditions in Modern Italy (Princeton, NJ: Princeton University Press).

Rawls, J. (1972), A Theory of Justice (Oxford: Oxford University Press).

Reed, D., ed. (1992), Structural Adjustment and the Environment (Boulder, CO: Westview Press).

Repetto, R., W. Magrath, M. Wells, C. Beer, and F. Rossini (1989), Wasting Assets: Natural Resources in the National Income Accounts (Washington, D.C.: World Resources Institute).

Robbins, L. (1932), An Essay on the Nature and Significance of Economic Science (London: Allen and Unwin).

Robinson, J. (1964), Economic Philosophy (Harmondsworth, Middlesex: Penguin Books).

Romer, D. (1996), Advanced Macroeconomics (New York: McGraw Hill).

Rose, R. (1999), "Getting Things Done in an Antimodern Society: Social Capital Networks in Russia", in P. Dasgupta and I. Serageldin, eds., Social Capital: A Multifaceted Perspective (Washington, D.C.: World Bank).

Russell, B. (1946), History of Western Philosophy (London: George Allen & Unwin).

Samuelson, P.A. (1947), Foundations of Economic Analysis (Cambridge, MA: Harvard University Press).

Samuelson, P.A. (1961), "The Evaluation of 'Social Income': Capital Formation and Wealth", in F.A. Lutz and D.C. Hague, eds., The Theory of Capital (London: MacMillan).

Scitovsky, T. (1976), The Joyless Economy (Oxford: Oxford University Press).

Sefton, J. and M. Weale (1996), "The Net National Product and Exhaustible Resources: The Effects of Foreign Trade", Journal of Public Economics, 61, 21-48.

Seierstad, A. and K. Sydsaeter (1987), Optimal Control with Economic Applications (Amsterdam: North Holland).

Sen, A. (1992), Inequality Reexamined (Oxford: Clarendon Press).

Serageldin, I. (1995), "Are We Saving Enough for the Future?", in Monitoring Environmental Progress, Report on Work in Progress, Environmentally Sustainable Development, World Bank, Washington, D.C.

Sidgwick, H. (1907), The Methods of Ethics (London: McMillan).

Singer, P. (1976), Animal Liberation (Cambridge: Cambridge University Press).

Skiba, A.K. (1978), "Optimal Growth with a Convex-Concave Production Function", Econometrica, 46(3), 527-540.

Solorzano R. et al. (1991), Accounts Overdue: Natural Resource Depreciation in Costa Rica (Washington, D.C.: World Resources Institute).

Solow, R.M. (1957), "Technical Change and the Aggregate Production Function", Review of Economics and Statistics, 39(3), 312-320.

Solow, R.M. (1974), "Intergenerational Equity and Exhaustible Resources", Review of Economic Studies, 41 (Symposium Issue), 29-45.

Solow, R.M. (1986), "On the Intergenerational Allocation of Exhaustible Resources", Scandinavian Journal of Economics, 88, 141-49.

Solow, R.M. (1992), "An Almost Practical Step Toward Sustainability", 40th Anniversary Lecture, Resources for the Future, Washington, D.C.

Squire, L. and H. Van der Taak (1975), Economic Analysis of Projects (Baltimore: Johns Hopkins University Press).

Starrett, D. (1988), Foundations of Public Economics (New York: Cambridge University Press).

Taylor, C.L. and D.A. Jodice (1983), World Handbook of Political and Social Indicators, Vol.1 (New Haven, Conn.: Yale University Press).

UNDP (United Nations Development Programme) (1991, 1998), Human Development Report (New York: Oxford University Press).

Weitzman, M.L. (1976), "On the Welfare Significance of National Product in a Dynamic Economy", Quarterly Journal of Economics, 90, 156-162.

Weitzman, M.L. (1998), "On the Welfare Significance of National Product Under Interest Rate Uncertainty", European Economic Review, 42, 1581-1594.

Wolfensohn, J.D. (1999), "A Proposal for a Comprehensive Development Framework", Processed, World Bank, Washington, D.C.

World Bank (1995), World Development Report (Washington, D.C.: World Bank).

World Bank (1996), Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development (Washington, D.C.: World Bank).

World Bank (1998), World Development Indicators (Washington, D.C.: World Bank).

World Commission (1987), Our Common Future, (New York: Oxford University Press).