VALUING OBJECTS AND EVALUATING POLICIES IN IMPERFECT ECONOMIES*

Partha Dasgupta

1. Introduction: Making Comparisons

In common parlance, we *value* when comparing objects and *evaluate* when comparing the relative merits of actions. The objects need not be concrete, they can be abstract (ideas), and evaluation is not restricted to a narrowly construed notion of action. We evaluate strategies, which are conditional actions, be they personal or collective ('I will do this if that happens', 'We will do that if he does this', and so forth). We evaluate policies as well, which can also be personal or collective. There is a sense in which valuation is passive, while evaluation signifies more of an active engagement. We frequently value in order to evaluate. But not always. We sometimes value simply because we wish to understand a state of affairs, such as the quality of life in a country.

Welfare economics studies life's quality, valuing objects and evaluating policies being only a means to measuring the quality of life and to discovering ways to improve it. When discussing policies, welfare economists typically address public policies, the sort of policies governments and international agencies are expected to ponder. They involve such matters as the character of public investment, the structure of taxes and transfers, property rights (ownership of firms, land, and resources; environmental legislation), international aid and agreements, and so forth.

Over the years, a good deal of my own research has been directed at a particular set of welfare concerns, namely, the economics of environmental and natural resources. Much of that too has been in the context of poor regions and the people who inhabit them. Inevitably, I reacted adversely to the fact that the natural environment is absent from national accounts, from quality-of-life indices and, more generally, from official development economics. I found it puzzling too that, in its turn, official environmental and resource economics made no contact with poverty in poor countries. The two fields of specialisation had passed each other by and had weakened in consequence.[1]

In great measure, their detachment from each other continues. For example, in responding to the inadequacies of Gross National Product (GNP) as an index of social well-being, one influential group of development economists seems content to study measures of *current* well-being (expectancy of life,

[1] I have grumbled about these deficiencies on a number of occasions. See Dasgupta (1982, 1993, 1997, 1998*a*, 2000).

infant survival, public expenditure) when describing the state of the world and devising prescriptions for governments.[2] To many, this has very limited appeal. It appears odd to ecologists, who are trained to study the many slow processes that influence long-term development possibilities and cannot help peering into the future. A seemingly natural retort to ecologists is that people come first and that, after all, present anguish should matter most. But it would be to miss the point. The present is the past's future. Moreover, the future has an unnerving habit of becoming the present. An effective response to ecologists would be to work within a framework for valuing and evaluating which combines present and future concerns. Economics has had such a framework in place for decades, namely, the Ramsey-Koopmans framework. I shall draw upon that literature here.

But with two significant differences:

First, official welfare economics has neglected the natural environment.[3] Secondly, intertemporal welfare economics was developed for a society in which the State is not only trustworthy, it also optimises on behalf of its citizens. Policy prescriptions emerging from the theory are for Utopia, or at worst, for what Meade (1989) called Agathotopia (the 'good society'). But they are not directly relevant for the world we have come to know, perhaps, most especially, for today's poor countries, the majority of which are a far cry from Agathotopia.[4]

Fortunately the principles of intertemporal welfare economics, such as the use of accounting prices to value objects and evaluate policies, can be extended even to dysfunctional societies.[5] In this paper I am concerned with valuation and evaluation in what should only for the sake of politeness be called *imperfect economies*. Being imperfect, I suppose that the economies in question are capable only of policy reforms. It transpires that policy reforms can be evaluated with the use of accounting prices even in economies where production possibilities are non-convex (see Appendix).

The plan of the paper is as follows:

The proceeding section is on valuing. We need indices of social well-being because we frequently wish to compare the lives of different groups of people at a given point in time, as well as through time.[6] We also need welfare indices because of our desire to compare the state of affairs in different places

---

[2] The annual Human Development Report of the United Nations Development Programme is a prominent case in point. The Report's Human Development Index (HDI) is in fact a hybrid. It is a linear function of (i) GNP per head, (ii) life expectancy at birth, and (iii) literacy. The problem with HDI is that (i) misprepresents future concerns hopelessly (it is insensitive to capital depreciation) and (ii) reflects only current well-being. (iii) would appear to capture both current and future concerns, but as it is an index only of human capital, it is unduly limiting.

[3] By 'official welfare economics', I mean, loosely speaking, the questions studied in such journals as the *Journal of Public Economics*.

[4] Arrow and Kurz (1970) is still the quintessential study of intertemporal welfare economics in Agathotopia. But normative public economics in general also has remained in Agathotopia (Atkinson and Stiglitz, 1980; Myles, 1995).

[5] Dasgupta and Mäler (2000a,b).

[6] For example, we may wish to compare the well-being of men and women, female-headed households and male-headed households, members of a particular denomination and the rest, and so forth.

(villages, districts, states, countries), so as to help determine in which way they differ and what, if anything, needs to be done.[7] In Section 2.1 I recount the role accounting prices should play in valuing goods and services and argue that if a given index is to be a useful surrogate for social well-being, it should be linear in quantities. I then argue in Section 2.2 (and prove in the Appendix) that the appropriate index for *intertemporal social well-being* (or *social well-being* for short) is *wealth*, where an economy's wealth is the accounting value of its entire stock of capital assets, including natural capital.

This means that the now-customary practice of viewing GNP (per head) as an index of social well-being is wrong. GNP is by definition insensitive to the depreciation of capital assets, including natural capital, and can mislead hopelessly. GNP could rise for an extended period even while wealth declines. GNP is a measure of economic activity, not social well-being. It means too that net national product (NNP) is no good either. It is possible for NNP to rise for an extended period, even while wealth is declining.[8]

In Section 2.3 the theory is put to work on some raw and rough data pertaining to the world's poorest regions (China, the Indian sub-continent, and sub-Saharan Africa), which together comprise half the world's population. The findings are sobering and contrast sharply from the assessments that have been made regularly by such international organisations as the World Bank and the United Nations Development Programme. The data imply that the Indian sub-continent and sub-Saharan Africa, comprising something like a third of the world's population, have over the past decades become poorer.

Section 3 is about policy evaluation. As I am interested in imperfect economies here, I take it that policy changes are in effect *policy reforms*, which are small perturbations to the prevailing policies (e.g., small investment projects). We need a criterion by which to evaluate policy reforms. That we have become used to inappropriate indices of social well-being probably is not unrelated to the fact that economic policy is frequently biased against the natural environment, and that policy choice often reflects insensitivity to non-market interactions among people. The reason they are probably not unrelated is that in poor countries transactions over environmental natural resources are commonly undertaken through non-market channels.

The effect on GNP growth would appear to be the most favoured criterion in terms of which policy changes are evaluated today. This is bad economics at work.

It transpires that, when evaluating policy reforms, we should seek to measure their effect on wealth. Now, Little and Mirrlees (1968, 1974) and Dasgupta *et al.* (1972) argued that the criterion in terms of which policy reforms (e.g., small investment projects) ought to be evaluated is their *present discounted value*

---

[7] In what follows, I use the terms 'welfare', 'well-being' and the 'quality of life' interchangeably.
[8] Dasgupta and Mäler (2000*b*). NNP is proportional to social well-being if, either utility is linear in consumption services, or the economy is stationary. Neither is believable. So NNP should be rejected as a welfare measure.

of the flow of accounting profits (PDV). But this *is* to evaluate them in terms of their effects on wealth.[9] So we have a unified framework in which to value and evaluate. The moral is this: whether we are valuing or evaluating, the object of study should be wealth. Viewed in terms of this finding, it should not surprise that Adam Smith inquired into the wealth of nations, not the Gross or Net National Product of nations, nor the Human Development Index of nations.

I have known these connecting results for some time, but still feel they are together a remarkable fact of life. I cannot think of any *a priori* reason why we should have expected the same set of weights to be appropriate for valuing objects and the same aggregate index, wealth, to be appropriate for both valuing and evaluating. There is a deep connection between valuing states of affairs and evaluating policies. It is one of those beautiful facts that social scientists are fortunate to unearth from time to time.

The PDV-index is linear in quantities. When estimated with care, it incorporates the perturbations to the flow of goods and services policy reforms create in both market and non-market institutions. Unhappily, ignoring the perturbations in non-market institutions is today common practice: it leads to the choice of wrong policy reforms.

Section 3 elaborates on these observations by considering three examples. In Section 3.1 I sketch various means by which non-market transactions occur. Sections 3.2-3.4 contain three examples of contemporary failure to take into account non-market interactions when public policies are debated. The example in Section 3.2 is a spatial miniature, involving economic aid to poor farmers sharing an irrigation system. The examples in Sections 3.3 and 3.4 are altogether grander and near-global. I present them so as to help understand contemporary debates on the effects of structural adjustment and freer trade on the poorest in poor countries.

2. Valuing

2.1. *Capital Assets and Accounting Prices*

An economy's productive base includes not only *manufactured capital*, *human capital*, and *knowledge*, but also *natural capital* and the economy's *institutions*. Together, they determine the production, allocation, and use of goods and services. A society's productive base is the source of its well-being.

The base itself is a diverse collection of durable objects, some tangible and alienable (buildings and machinery, land and animals, trees and shrubs), some tangible but non-alienable (people, the oceans), some intangible but alienable (codified pieces of knowledge, such as patentable ideas), some intangible and non-alienable (air, skills, the legal framework, and cultural coordinates), and

---

[9] However, Little and Mirrlees demonstrated their claims in the context of Agathotopia. Dasgupta, Marglin and Sen asserted that PDV is the correct index even in imperfect economies, but offered no rigorous proof. In the Appendix I use a simplified model in Dasgupta and Mäler (2000*a,b*) to provide a proof.

some that are yet to be defined in an acceptable way (*social capital*).[10] This heterogeneity poses a problem. No doubt it serves heuristic purposes to refer to all but people as capital goods and then to say that output is produced by people and capital goods, but explaining that to economic statisticians is not much use. They ask how all the bits and pieces called capital goods are to be measured and valued.

The objects they seek to measure are *accounting prices*, which reflect the social worth of goods and services. The accounting price of something is the improvement in the quality of life that would be brought about if a unit more of that thing were made available costlessly.[11]

It should be apparent from their definition that the magnitudes of accounting prices depend upon four, related factors: (a) the conception of social welfare being adopted, (b) the size and composition of existing stocks of assets, (c) production and substitution possibilities among goods and services, and (d) the way resources are allocated in the economy. It is as well to illustrate them here qualitatively.[12]

Consider first (a). If special weight is placed on, say, species preservation, the accounting price of species would be high, other things remaining the same. To illustrate (b), imagine that due to overuse in the past, very little of a distinctive resource remains. Assume too that the resource is useful in production. Then, other things remaining the same, it is valuable. Its accounting price is high. Suppose next that a particular resource has no near-substitutes in either production or consumption. Then, other things remaining the same, it is valuable. Its accounting price is high. On the other hand, if a resource has substitutes in large quantities, then even if it were dwindling, its accounting price would be low. These are illustrations of (c).

Finally, to illustrate (d), imagine that the social institutions in a country are dysfunctional, so that a number of resources are put to use very inefficiently. Then, other things remaining the same, the accounting prices of those resources would be *low* relative to the goods and services that are used efficiently. As this could seem paradoxical, it requires an explanation:

If a commodity is wasted and the prevailing institutions are unlikely to change, the social worth of an additional unit of the good would be low. Its accounting price would be low. Of course, if the prevailing institutions are dysfunctional, there is a strong case for establishing better ones. Similarly, if current policies are wrong-headed, they ought to be revised. If the project being evaluated is an institutional reform (or even a policy reform) under which the resources in question would be better used, their accounting prices would not be low. Accounting prices do a lot of work for us in summarising information about an economy.

If the good is not a 'good', but is instead a 'bad' (sulfur emission), its

---

[10] On social capital and the difficulties surrounding its definition, see the essays in Dasgupta and Serageldin (1999).

[11] A formal definition is provided in the Appendix. An alternative name is *shadow price* (Dasgupta *et al.* 1972).

[12] The examples are drawn from natural capital. Notice that (b) and (c) are closely related.

accounting price is negative. But even if a good is a 'good', its accounting price could be negative if the economy's institutions are bad: offering an extra unit of the good to someone could lower social well-being. Examples include common-property resources suffering from the tragedy of the commons. Carbon is emitted into the atmosphere when fossil fuels are burnt. The use of fossil fuels by motorists yields not only private benefits, but also collective losses (enhanced greenhouse effect). If emissions are untaxed, private benefits would not include the collective damage caused by the combustion of fossil fuels. Imagine now that the collective damage arising from a marginal increase in the use of fossil fuels exceeds private benefits. An additional unit of fossil fuels awarded to a motorist would then lower social well-being. The accounting price of fossil fuels in a motorist's vehicle would be negative.

Ways of estimating accounting prices have been devised by economists for various types of assets, including natural capital. As we would expect, at one extreme are some that are relatively easy to estimate (e.g., because market prices are a good approximation), while at the other, there are those that are impossible to estimate.[13]

Conceptually, the most problematic is social capital. Economists have come down hard on the concept.[14] In his work on Italy, Putnam (1993) pursued an interesting route for measuring social capital. Putnam's unit of analysis was a region, and in cross-regional data he found a strong positive relationship between economic performance and measures of 'civic engagement', such as membership in unions and choral societies.[15] From this finding to the thought that civic engagement matters for economic performance is a natural step. It is a step Putnam took with relish.

I do not believe economists question that move. What bothers them is a measurement problem. The form of civic engagement evolves over time. Even when choral societies are hard-pressed to attract new recruits, it could be that citizens are discovering new ways to connect with one another (e.g., via the internet), which itself could be the reason why choral societies are hard-pressed. Measurement problems abound in the search for social capital. Nor were matters helped by the fact that Putnam defined social capital to be '... features of social organisation, such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions'.[16] As a characterisation this appears beguiling, but it suffers from a weakness: it encourages us to amalgamate in turn beliefs, behavioural rules and such forms of capital assets as interpersonal networks, without offering a hint as to how they are to be amalgamated.

A large contemporary literature on social capital interprets the concept as an economy's institutions.[17] Admittedly, a name is but a name, but some

[13] For a summary account, see Dasgupta (2001).
[14] See, especially, Arrow (1999) and Solow (1999).
[15] Inter-village data from poor countries have revealed similar relationships. See, for example, Narayan and Pritchett (1999).
[16] Putnam (1993, p. 167).
[17] See, for example, the Special Issue of the *Journal of Interdisciplinary History*, 1999, vol. 29(3), on 'Patterns of Social Capital: Part I'.

names can mislead. To call a society's institutions 'capital' is less helpful than may seem. Institutions are distinct from other forms of capital, in that they *guide* the allocation of resources (among which are the capital goods themselves!). Institutions are better seen as *resource allocation mechanisms*, a formal definition of which is provided in the Appendix.

We can now appreciate why economic statisticians left social capital aside from their accounting scheme. But they did not have to neglect as much of natural capital as they have. Current accounting practices have been shaped partly by developments in economic theory and partly by internal dynamics in accounting. For example, while the value of agricultural land is included in accounting systems, watersheds are not valued in their entirety. Of course, bits of watersheds are valued, namely, those supplying commercial products. However, most of the myriad of non-commercial services they provide are excluded. Nor are the commercial benefits bestowed on enterprises outside a watershed included.

One explanation for the bias is that, until recently there was little theory to guide economic statisticians in the direction of the natural environment. But the necessary theory is now in hand.[18] There is no reason why national accounting systems should remain confined in the way they have been so far.

2.2. *Wealth*

Taken together, investment in manufactured capital, human capital, the natural environment, and expenditure on research and development change the productive base of an economy. It is in the nature of things that the mix of the base varies across space, time, and circumstances. Possibilities of substituting one type of capital good for another in production affects the way the mix changes. Although seemingly innocuous, enlarging our conception of the productive base of an economy has significant implications for the way development processes are viewed. We confirm this below.

A country's wealth is the social worth of its capital assets. To formalise the idea, let K_{it} be the quantity of the ith manufactured asset, H_{jt} the quantity of the jth form of human capital, S_{kt} the quantity of the kth natural capital, and Z_{mt} the stock of the mth type of knowledge at date t.[19] Next, let p_{it}, h_{jt}, q_{kt}, and r_{mt}, respectively, denote their accounting prices. The economy's wealth at t can be expressed as:

$$W_t = \Sigma_i(\,p_{it}K_{it}) + \Sigma_j(\,h_{jt}H_{jt}) + \Sigma_k(\,q_{kt}S_{kt}) + \Sigma_m(\,r_{mt}Z_{mt}). \tag{1}$$

What do we mean by the ith manufactured asset or the kth natural capital at date t? How should we decide that a pair of assets ought to be regarded as distinct, rather than similar? Obviously, we should include physical and chemical properties in an asset's attributes. But we should include more. For

---

example, transport costs for traditional manufactured goods are a reason why location matters. Transport costs can assume an extreme form in the case of natural capital. The ecological role of a species of plants is frequently site-specific. A species in any one location is a different asset from that same species elsewhere.

In imperfect economies, the institutions governing the use of an asset matter too. Even if they possess similar ecological properties, a private fishery is a different asset from a fishery to which there is free access. For classifying assets, ownership matters.

Thus far theory. In practice, refined partitioning is not feasible. Economic statisticians are compelled to lump together what are often different assets.

A country's wealth is the sum of the social worth of all the bits and pieces of manufactured capital, human capital, natural capital, and knowledge. Of course, a figure for wealth is meaningless in itself, but differences in wealth do have meaning. We may ask, for example, if, correcting for demographic differences, a country is *wealthier* now than it was earlier. It is useful to ask the question because, as we noted earlier, wealth is an index of social well-being.

As an index, wealth has the merit of being *linear* in the quantities of assets, accounting prices being the weights awarded to quantities. A country's wealth in a given period is its wealth in the previous period plus net investment made during the previous period. Wealth increases if, and only if, there is net investment in capital assets.

It helps to formalise this. For convenience, regard time to be continuous. We then define net investment in period t to be:

$$I_t = \Sigma_i(p_{it}\,dK_{it}/dt) + \Sigma_j(h_{jt}\,dH_{jt}/dt) + \Sigma_k(q_{kt}\,dS_{kt}/dt) + \Sigma_m(r_{mt}\,dZ_{mt}/dt). \quad (2)$$

I will call I_t *genuine investment* at t. I_t measures the change in wealth at t in constant accounting prices.

Imagine that population is constant and the economy is closed. In the Appendix (Proposition 1) it is shown that I_t is positive if and only if social well-being increases at t. This equivalence can be stated in a different way. Invoke the accounting identity, that NNP is the sum of aggregate consumption and genuine investment. It follows that a country's wealth increases if, and only if, aggregate consumption is less than NNP. NNP has no further ethical significance. As an index of social well-being, NNP has to be rejected.

The fundamental point, then, is this: there has to be genuine investment if wealth is to increase. Estimates of investment in contemporary national accounts are in error because they ignore many of the changes in the natural-resource base that are brought about by economic activity.

Genuine investment measures the present discounted value of changes in the consumption stream that result from it.[20] This finding allows us to interpret investment in the productive base in terms of changes in the determinants of social well-being brought about by it. If genuine investment is

---

[20] This is proved in the Appendix (Proposition 3).

positive, the country becomes wealthier. Contrariwise, if it is negative, it becomes poorer.

Of course, if the population is too large and the natural environment overly depleted, it may not be possible to increase wealth. The findings I am describing here are of the 'if and only if' kind, they do not say on their own if substitution possibilities between the natural environment and other forms of capital are sufficiently large for wealth to increase at the expense of Nature. Imagine, for example, that substitution possibilities are limited and the economy's institutions are profligate in the use of natural resources. Then the quality of life will not be sustainable. This would be signalled by the fact that, at some future date, accounting prices will assume such values as to make it impossible for genuine investment to be positive: natural capital will have to be run down if there is to *be* any consumption. Social well-being declines when genuine investment is negative. Movements in social well-being and genuine investment are two sides of the same ethical coin.

The ethical significance of NNP is now clear: NNP offers an upper bound on consumption if a country's wealth is to increase. Since conventional estimates of NNP do not include the accounting value of changes in natural capital, it can be that a country is recorded as investing at a positive rate even while its genuine investment is negative. For a long while GNP and NNP per head could grow even while the country becomes poorer. There is no paradox here.[21]

The assumption that the size of the population is constant is wrong. Suppose then that population is projected to increase. An adjustment needs to be made to estimates of genuine investment so as to allow for increases in population size. In the Appendix we will see how this should ideally be done. Since ecological processes are typically non-linear, the adjustment is not straightforward. But as an approximation, one may estimate *wealth per head* and track it over time. In applying the theory to data on investment in poor countries, this is what I do below.

2.3. *Genuine Investment: Applications*[22]

Reporting studies undertaken at the World Bank, Hamilton and Clemens (1999) have provided estimates of genuine investment in a number of countries. They call it 'genuine saving'. The authors included in a country's productive base its manufactured, human, and natural capital. There is a certain awkwardness in some of the steps the authors took to estimate genuine investment. For example, investment in human capital in a given year was taken to be public expenditure in education. It is an overestimate, because

---

[21] These ideas have recently been put to use in assessing various long-term forecasts of world food production. See Dasgupta (1998*b*) and Daily *et al.* (1998).

[22] That an economy needs to raise the worth of its productive base if social well-being is to increase was the topic of discussion, starting in 1993, among members of an Advisory Council created by Ismail Serageldin, then Vice President for Environmentally Sustainable Development at the World Bank. Serageldin (1995) provides an outline of empirical work on genuine investment that was in consequence initiated in his Vice Presidency.

each year people die and take their human capital with them. This is depreciation, and should have been deducted.

Among the resources making up natural capital, only commercial forests, oil and minerals, and the atmosphere as a sink for carbon dioxide were included (not included were water resources, forests as agents of carbon sequestration, fisheries, air and water pollutants, soil, and biodiversity). So there is an undercount, possibly a serious one. Nevertheless, one has to start somewhere, and theirs is a useful compendium of estimates.

Being a global commons, Earth's atmosphere poses an intriguing problem. When a country adds to the atmosphere's carbon content, it reduces the value of the commons. In calculating the value of the change in the country's capital assets, how much of the reduction should we include?

Two possibilities suggest themselves.[23] One is to attribute to each country the fraction of Earth's atmosphere that reflects the country's size relative to the world as a whole, using population as a means of comparison, or GNP, or whatever. The other is to regard the global commons as every country's asset. In that case, the entire cost of global warming inflicted by a country would be regarded as that country's loss. Hamilton and Clemens (1999) follow the latter route.[24] They use US $20 as the figure for damages caused by a tonne of emited carbon dioxide.[25]

The accounting value of forest depletion is taken to be the stumpage value (market price minus logging costs) of the quantity of commercial timber and fuelwood harvested in excess of natural regeneration rates. This is an awkward move, since the authors do not say what is intended to happen to the land that is being deforested. If the deforested land is converted into an urban sprawl, the new investment in the sprawl would be accounted for in conventional accounting statistics. But if it is intended to be transformed into farmland, matters are different: the social worth of the land as farm should be included as an addition to the economy's capital base.

Despite these limitations in the data, it is instructive to put the theory to work in the context of the world's poorest regions. Table 1 does that. The account that follows covers sub-Saharan Africa, the Indian sub-continent, and China. Taken together, they contain nearly half the world's population. They also comprise pretty much all the world's poorest countries.

The first column of figures in Table 1 contains estimates of genuine investment, as a proportion of GNP, in Bangladesh, India, Nepal, Pakistan, China, and sub-Saharan Africa, over the period 1970–93. Notice that Bangladesh, Nepal, and sub-Saharan Africa have disinvested: their productive base has shrunk during the period in question. In contrast, genuine investment was positive in China, India, and Pakistan. This could suggest that the latter countries were wealthier at the end of the period than at the beginning. But when population growth is taken into account, the picture changes.

---

[23] Dasgupta *et al.* (1995).
[24] Under optimum global management, the country would be required to pay the total cost in the form of an international tax.
[25] The estimate is due to Fankhauser (1994).

Table 1.

Genuine Investment and Capital Deepening in Selected Regions: 1970−93

	I/Y^*	$g(L)$†	$g(W/L)$‡	$g(Y/L)$§	$g(HDI)$‖
Bangladesh	−0.013	2.3	−2.60	1.0	3.3
India	0.080	2.1	−0.10	2.3	2.2
Nepal	−0.024	2.4	−3.00	1.0	5.3
Pakistan	0.040	2.9	−1.90	2.7	1.8
Sub-Saharan Africa	−0.028	2.7	−3.40	−0.2	0.9
China	0.100	1.7	0.80	6.7	−0.2

* I/Y: genuine investment as proportion of GNP. *Source*: Hamilton and Clemens (1999, Table 3).
† $g(L)$: average annual percentage rate of growth of population, 1965−96. *Source*: World Bank (1998, Table 1.4).
‡ $g(W/L)$: average annual percentage rate of change in *per capita* wealth.
§ $g(Y/L)$: average annual percentage rate of change in *per capita* GNP, 1965−96. *Source*: World Bank (1998, Table 1.4).
‖ $g(HDI)$: average annual percentage rate of change in UNDP's Human Development Index, 1987−97. *Source*: UNDP.
Assumed output-wealth ratio: 0.25.

The second column of figures in Table 1 contains the annual percentage rate of growth of population in the various places over the period 1965−96. All but China have experienced rates of growth in excess of 2% per year, sub-Saharan Africa and Pakistan having grown in numbers at nearly 3% per year. We now want to estimate the average annual change in wealth *per capita* during 1970−93. To do this, we should multiply genuine investment as a proportion of GNP by the average output-wealth ratio of an economy to arrive at the (genuine) investment-wealth ratio, and then compare changes in the latter ratio to changes in population size.

Since a wide variety of natural assets (human capital and various forms of natural capital) are unaccounted for in national accounts, there is an upward bias in published estimates of output-wealth ratios, which traditionally have been taken to be something like 0.30. In what follows, I use 0.25 as a check against the upward bias in traditional estimates. This is almost certainly still a conservatively high figure.

The third column in Table 1 contains my estimates of the annual percentage rate of change in *per capita* wealth. The procedure for this has been to multiply genuine investment as a proportion of GNP by 0.25, and to substract the annual percentage rate of growth of population from the product. This is a crude way to adjust for population change, but more accurate adjustments would involve greater computation.

The striking message of the third column is that all but China have *decumulated* their productive base during the past 30 years or so. This may not be a surprise in the case of sub-Saharan Africa, which is widely known to have regressed in terms of most socio-economic indicators. But the figures for Bangladesh, India, Nepal, and Pakistan should cause surprise.

How do changes in *per capita* wealth compare with changes in conventional measures of the quality of life? The fourth column of the table contains estimates of the annual percentage rate of change in *per capita* GNP during

1965–96; and in the fifth column I have compiled figures for the average growth rate in UNDP's Human Development Index (HDI) over the period 1987–97.

Notice how misleading our assessment of long-term economic development in the Indian sub-continent would be if we were to look at growth rates in GNP per head. Pakistan, for example, would be seen as a country where *per capita* GNP grew at a healthy 2.7% per year, implying that the index *doubled* in value between 1965 and 1993. In fact, the average Pakistani became poorer by a factor of nearly *two* during that same period.

Bangladesh too has disinvested in her productive base. She is recorded as having grown in terms of *per capita* GNP at a rate of 1% per year during 1965–96. In fact, at the end of the period the average Bangladeshi was *less than half* as wealthy as she was at the beginning.

The case of sub-Saharan Africa is, of course, especially sad. At an annual rate of decline of *per capita* wealth of 3.5%, the average person in the region becomes poorer by a factor of two every 20 years. The ills of sub-Saharan Africa are routine reading in today's newspapers and magazines. But the ills are not depicted in terms of a decline in wealth. The table reveals that sub-Saharan Africa has experienced an enormous decline in its productive base over the past three decades. It will take years for the region to recover, if it is at all able to do so.

India can be said to have avoided a steep decline in its productive base. But she has been at the thin edge of economic development, having managed not quite to maintain her productive base relative to population size. If the figures are taken literally, the average Indian was slightly poorer in 1993 than in 1970.

Even China, so greatly vaunted for her progressive economic policies, has just managed to accumulate wealth in advance of population increase. For a poor country, a growth rate of 0.8% per year in wealth per head is not something about which one gets too excited. In any event, a more accurate figure for output-wealth ratio would almost surely be considerably lower than 0.25. Moreover, the estimates of genuine investment do not include soil erosion or urban pollution, both of which are thought to be especially problematic in China.[26]

What of HDI?[27] In fact it misleads even more than *per capita* GNP. As the third and fifth columns show, HDI offers precisely the opposite picture of the one we should obtain when judging the performance of countries. I do not have an intuitive feel for what may or may not be a healthy growth rate for HDI, but for sub-Saharan Africa the index *grew* during the 1990s, at 0.9% per year. Bangladesh and Nepal have been exemplary in terms of HDI. However, both countries have decumulated their assets at a high rate.

These are all rough and ready figures, but they show how accounting for human and natural capital can make for substantial differences in our concep-

---

[26] Hussain *et al.* (2000) contains an analysis of why China has been the economic success it is widely judged to have been in recent years. There is no mention though of what may have been happening to China's natural-resource base in the process of her economic development.

[27] I am grateful to my colleague, Sriya Iyer, for suggesting that I should check what HDI says about the progress of the poorest nations.

tion of the development process. The implication should be heart-breaking: the Indian sub-continent and sub-Saharan Africa, two of the poorest regions of the world, comprising something like a third of the world's population, have over the past decades become even poorer. In fact, some of the countries in these regions have become a good deal poorer.

3. Evaluating

3.1. *Non-Market Interactions*

It is easy enough to characterise policy reforms in terms of the perturbations they create in an economy, it is altogether more difficult to identify the disturbances. Any system, human or otherwise, responds when perturbed. A policy change in an imperfect economy can create all sorts of effects rippling through unnoticed by those who are not affected, for the reason that there may be no public signals accompanying them. Tracing the ripples requires an understanding of both market and non-market interactions.

  Many economic interactions take place through non-market channels. Transactions involving environmental services are examples, as are those involving the management of common-property resources. In poor countries there are numerous other examples such as insurance and credit. For example Udry (1994) has reported that as recently as the late 1980s more than 90% of the value of all loans in Nigeria were obtained from what in the development literature is called the 'informal sector', which includes not only informal money lenders, but also the family and the kinship. Udry presents findings from a survey conducted on 400 households in four Nigerian villages. He found that nearly all credit transactions were either between relatives or between households in the same village. No written contracts were involved, nor did the agreements specify the date of repayment or the amount to be repaid. The same data shows that repayment of loans depends on the debtors' ability to pay, suggesting that 'credit' can assume the form of 'insurance' under long-term relationships in poor countries.[28]

  On what basis are they sustained? Four mechanisms come to mind. First, innumerable transactions occur because the people involved care about one another and trust one another to carry out their obligations. The household best exemplifies institutions which are based on care and affection. Secondly, there can be an external enforcer of agreements. It could be that an agreement is translated into an explicit contract and enforced by an established structure of power and authority. This may be the State, as in the case of contracts in the large numbers of markets operating throughout the world. But it need not be the State and is the reason I am invoking the mechanism here. In rural communities, for example, the structure of power and authority are in some cases vested in tribal elders (as in nomadic tribes in sub-Saharan Africa), in others in dominant landowners, feudal lords, chieftains, and priests.

  On occasion there are attempts to make rural communities mini-republics

---

[28] Udry (1993).

in certain spheres of life. Village Panchayats in India try to assume that form. The idea is to elect offices, the officials being entrusted with the power to settle disputes, enforce contracts (be they codified or only tacit), communicate with higher levels of State authority, and so forth.[29]

The question why such a structure of local authority as may exist is accepted by people is a higher-order one, akin to the question why people accept the authority of the State. The answer is that general acceptance itself is self-enforcing behaviour: when a sufficiently large number of others accept the structure of authority, each has an incentive to accept it, the personal cost of non-compliance (for example, a stiff jail sentence) being too high.

A third basis of non-market interactions is a perverse one, being reliant on an absence of well-defined property rights. The theory of economic externalities is founded on their absence.

However, where people encounter one another repeatedly in similar situations, agreements could be honoured even if people are not disposed to be honest, and even if an authority is not available to enforce agreements. This mechanism, where people are engaged in long-term relationships (among people who do not necessarily care for one another personally), is an ingredient in theories of social capital and is the fourth basis upon which interactions occur.

Long-term relationships in transactions involving land, labour, credit, and insurance have recently been studied by economists and political scientists with the same care and rigour they used to invest in the study of markets and the State.[30] There is now a large body of work on the ways in which people cope with resource scarcity when there are no formal markets for exchanging goods and services across time, space, and circumstances and when the State is ineffective. The literature offers us a way to understand how people, both individually and collectively, respond to policy changes.

In the following sections I offer three examples of contemporary failure to take into account non-market interactions when public policies are debated.

3.2. *Managing Irrigation Systems*

For many years, the political scientist, Elinor Ostrom, has been studying the management of common-property resources in various parts of the world.[31] In her work on collectively-managed irrigation systems in Nepal, she has ac-

---

[29] Robert Wade's account of local enforcement of the allocation of benefits and burdens in rural South India describes such a mechanism in detail (Wade, 1988). Forty-one villages were studied, and it was found that downstream villages (those facing an acute scarcity of water) had an elaborate set of rules, enforced by fines, for regulating the use of water from irrigation canals. Most villages had similar arrangements for the use of grazing land. Wade reports that elected village councils (Panchayats) appoint agents who allocate water among different farmers' fields, protect crops from grazing animals, collect levies, and impose fines.

Baland and Platteau (1996, p. 217) write about 'water masters' in fishing groups in the Niger River delta who regulated the use of the local fisheries.

[30] See the essays in Hoff *et al.* (1993) and Dasgupta and Serageldin (1999).

[31] Local common-property resources have often been managed collectively by those having historical rights to them. See, for example, Ostrom (1990) and Baland and Platteau (1996).

counted 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 some farmers being head-enders, while others are tail-enders.[32] 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 headworks made of stone, trees, and mud. Both sets of parties can in principle gain from cooperation. Because their fortunes would differ greatly if they did not cooperate, cooperative arrangements would be expected to display asymmetries, and they do so display.[33]

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. What could be better, you might ask. But she observed that those canal systems that had been improved were frequently in worse repair among tail-enders 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 do not 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.

3.3. *Structural Adjustment and the Natural Environment*

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, under which a plethora of taxes, subsidies, and direct controls introduced by governments over decades were reduced under pressure from the World Bank and the International Monetary Fund. The programmes were designed to encourage growth in GNP.

Many have criticised the way structural adjustment programmes were implemented. Some have pointed to the additional hardship many of the poor have experienced in their wake. Others have suggested that, in order to reduce deficits, governments embarked on economic programmes that were particu-

---

[32] Ostrom (1996).
[33] For analyses of why we would expect this, see Nash (1950) and Luce and Raiffa (1957).

larly harsh on the natural environment. Still others have argued that the two effects have come in tandem. They have suggested that structural adjustment programmes have encouraged countries to raise export revenue by depleting natural capital in a rapacious manner. Those who depend directly on the natural-capital base would be expected to get hurt under such a pattern of economic growth in an imperfect economy.

It is, however, easy to argue that structural adjustment programmes, facilitating as they did the growth of markets and reductions in government deficits in poor countries, were necessary. And it has been so argued by proponents of the programmes. It may appear easy to dismiss growth-oriented policies on grounds that they do not make for poverty alleviation, but both theory and evidence tell otherwise: they are not as ineffective in reducing poverty as is frequently claimed.[34]

I want to suggest that *both* proponents and opponents of the programmes may be right. Growth of markets and reductions in government deficits benefit many, but they can simultaneously make vulnerable people face additional economic hardship occasioned by environmental degradation. There are several pathways by which this can happen. Here I sketch one.

An easy way for the State to earn revenue in countries endowed with forests is to issue timber concessions. The State can exercise its rights to forests that are public property by a judicious use of force to evict long-term dwellers. Timber concessions can then be sold to favoured firms, reducing government deficit while simultaneously enlarging the private bank balances of officials. Forests are an easy target of usurpation by the State because there are mostly no legal documents proving ownership.[35]

I leave aside the losses incurred by those evicted, because there is nothing really to say on the matter other than platitudes. I want to think instead about concessions made on forests in the uplands of a watershed so as to consider the ecological pathways by which deforestation inflicts damage on people in the lowlands (siltation, increased incidence of flooding, and so forth).[36] It pays to study them in terms of the assignment of property rights. The common law in many poor countries, if we are permitted to use this expression in a universal context, in principle recognises pollutees' rights. So it is the timber merchant

---

[34] For example, by the United Nations Development Programme in its annual *Human Development Report* (especially, UNDP, 1995).
   The links between growth and poverty reduction should be expected to be subtle. For example, Dollar and Kraay (2000) present cross-country evidence that growth in GNP per head has been positively correlated with poverty reduction. By the latter the authors mean a reduction in the percentage of people below a poverty line. Being a macroeconomic statistic, their measure is unable to disclose what happened to people who remained poor, whether some became poorer than they were before. I am concerned with this sort of possibility in the text.

[35] Colchester (1995) has recounted that political representatives of forest-dwellers in Sarawak, Malaysia, have routinely given logging licenses to members of the state legislature. Primary forests in Sarawak are expected to be depleted within the next decade or so. Cruz and Repetto (1992), Reed (1996), and Seymour and Dubash (2000) describe other pathways by which structural adjustment programmes have been unfriendly to the natural environment.

[36] The example is taken from Dasgupta (1990). Hodgson and Dixon (1992) is a case-study on logging and its impact on fisheries and tourism, in Palawan, the Philippines, that illustrates the example well. Chichilnisky (1994) has developed the argument in the text in a more general context.

who, in principle, would have to pay compensation to downstream farmers for the right to inflict the damage that goes with deforestation. However, even if the law sees the matter in this light, there is a gulf between the 'written' law and the enforcement of law. When the cause of damage is hundreds of miles away, when the timber concession has been awarded to public land by the State, and when the victims are a scattered group of poor farmers or fishermen, the issue of a negotiated outcome does not usually arise. But when the timber merchant is not required to compensate downstream farmers and fishermen, the private cost of logging is less than its social cost. From the social point of view we would expect excessive deforestation of the uplands. We would also expect that resource-based goods would be underpriced in the market (say, in export markets). The less roundabout is the production of the final good, the greater would this underpricing be, in percentage terms. Put another way, the lower is the value that is added to the resource in the course of production, the larger is the extent of this underpricing of the final product. The accounting price of timber being greater than its market price, there is an implicit subsidy on primary forest products, possibly on a massive scale. Moreover, the (export) subsidy is paid not by the general public via taxation, but by some of the most disadvantaged members of society (the sharecropper, the small landholder or tenant farmer, the fisherman). The subsidy is hidden from public scrutiny, that is why it is not acknowledged officially. But it is almost certainly there. We should be in a position to estimate such subsidies. As of now, we have very few official estimates.

3.4. *Poverty and Freer Trade*

The happenings in Seattle at the end of 1999 and the response of those who regard free trade as being good for everyone offer an example similar to that concerning structural adjustment programmes. Public discussions on the appropriate role of the World Trade Organisation (WTO) are now routinely conducted in terms of an alleged battle between multi-national companies and hapless governments in poor countries. But the poor in poor countries are not the same as the governments who rule over them. There should be no question today that increased international trade has benefited many and arbitrary restrictions on trade have harmed many. But freeing trade in the presence of externalities can be predicted to hurt segments of the population. Externalities are particularly rampant in poor countries, where markets and non-market institutions co-exist and support similar types of transactions; insurance and credit, for example.

All societies rely on a mix of markets and communitarian institutions. The mix shifts through changing circumstances, as people find ways to circumvent difficulties in realising mutually beneficial transactions. Arnott and Stiglitz (1991) have developed a formal account of the externalities that are sustained when market and non-market institutions supply the same commodity. Their purpose was to show how the presence of non-market institutions can prevent people from transacting as much in the market as they should for their

collective good. I want to present a case offering the opposite moral, namely, that expansion of markets can destroy non-market institutions and make certain vulnerable groups worse off. Economic analysis can identify the kinds of people who would get hurt when trade expansion occurs in the absence of appropriate safety nets or compensations. Here is a pathway that may well be powerful.[37]

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

Consider 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 someone who applies a low rate to discount future costs and benefits of alternative courses of action. I assume as well that the parties in question are not separately mobile (although they could be collectively mobile, as in the case of nomads); 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.[38] But the threat of sanctions would cease to have potency if opportunistic behaviour became personally more attractive. This can happen if formal markets grow nearby and uncorrelated migration accompanies the growth of those markets. As opportunities outside the village improve, those with lesser ties (young men) are more likely to be able take advantage of them and make a break with those customary obligations that are enshrined in prevailing social norms. Those with greater domestic attachments would perceive this and 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 (women, the old, and the very young) worse off. This is a case where improved institutional performance elsewhere (growth of markets in the economy at large) has an adverse effect on the functioning of a local, non-market institution.

To the extent social norms weaken, communal management systems of local resource bases erode, as free-riding goes unpunished. So there can be a chain of events, leading from growth of markets elsewhere, through a deterioration of the local resource-base, to greater hardship for those unable to take advantage of growing opportunities elsewhere (owing to an absence of roads

---

[37] de Soto (2000) has argued that the process of globalisation can leave the poor behind because frequently they do not have titles to the capital with which they work (land). They are unable to offer collaterals for loans. The example I have offered in the text is of a different kind from his.

[38] Fudenberg and Tirole (1991) contains an account of (credible) equilibrium strategies in repeated games.

to transport their produce, to a lack of human capital, or whatever). Freeing trade without considering safety-nets for those who are vulnerable to the erosion of communitarian practices is defective policy. It has been argued that such safety-nets are the responsibility of governments and that international agreements on trade expansion are a different matter. The former is certainly true, but the latter does not follow from it. In an imperfect world it matters very much who gets to move first. If there is no guarantee that governments will put in place the needed safety-nets, the consequences of trade expansion can be expected to be quite different from the consequences if there are guarantees that governments will do their job. Even for the WTO governance is at the heart of the matter, not trade.

University of Cambridge and Beijer International Institute of Ecological Economics, Stockholm

Date of receipt of final transcript: January 2001

Appendix

A.1. *The Model*

We consider an economy where the production of goods and services requires labour, manufactured capital and natural resources. For purposes of illustration, I focus on one type of natural capital: extractive resources. I assume they are inputs in production (oil and natural gas, timber, water, agricultural land). For simplicity of exposition, the economy is assumed to be both closed and deterministic (but see Section A.7).

Time is denoted by $t(\geqslant 0)$ and is assumed to be continuous. Imagine that there is an all-purpose, non-deteriorating durable good, whose stock at t is $K_t(\geqslant 0)$. The good can be consumed or reinvested for its own accumulation. For the moment I assume that population size is constant, which means that we may as well ignore it.

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 aggregate output as Y and assume that $Y = F(K, L, R)$. GNP at t is then $Y_t = F(K_t, L_t, R_t)$. F is taken to be an increasing and continuously differentiable function of each of its variables. *I do not assume that F is concave.*

Let $C_t(\geqslant 0)$ denote aggregate consumption at t. Net accumulation of manufactured capital satisfies the condition:

$$dK_t/dt = F(K_t, L_t, R_t) - C_t. \tag{A.1}$$

The aggregate stock of natural capital is denoted by $S_t(\geqslant 0)$. Resources can be extracted costlessly. Let their natural rate of growth be $M(S_t)$. $M(S)$ is a continuously differentiable function.[39]

The dynamics of the resource base can therefore be expressed as:

$$dS_t/dt = M(S_t) - R_t. \tag{A.2}$$

As with F, I do not assume that M(.) is a concave function. This is significant because ecological processes are frequently subject to non-convex dynamics, displaying, for example, threshold effects. The reason we are able to accommodate non-convex production structures is that I am assuming that the government is capable only of

---

[39] 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.

policy reform. For an optimising government the matter would be different. As the Second Fundamental Theorem of Welfare Economics makes clear, production processes need to be convex if it is desired that the optimum allocation be implemented in a decentralised fashion.

Current social well-being is taken to depend on consumption and leisure. I write this as $U(C, L)$, 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.

At t, intertemporal social well-being (social well-being for short) is,

$$V_t = \int_t^\infty U(C_\tau, L_\tau) e^{-\delta(\tau-t)} d\tau, \tag{A.3}$$

where $\delta(>0)$, a constant, is the discount rate on future well-being.

A.2. *Resource Allocation Mechanisms*

Let $\{C_t, L_t, R_t, K_t, S_t\}_0^\infty$ denote an *economic programme*, from the present ($t = 0$) to the indefinite future. Consider an economy facing the technological constraints in equations (A.1) and (A.2). In addition, it faces institutional constraints (sometimes called transaction and information constraints). By the economy's institutional structure I mean market structures, the structure of property-rights, tax rates, non-market institutions for credit and insurance, the character of various levels of government, and so forth. I assume that the institutional structure is given and known. The initial capital stocks (K_0, S_0) are given and known. If in addition, the behavioural characteristics of the various agencies in the economy (i.e. those of households, firms, the government, and so on) were known, it would be possible to make an economic forecast, by which I mean a forecast of the economic programme $\{C_t, L_t, R_t, K_t, S_t\}_0^\infty$ that would be expected to unfold. Call this relationship a *resource allocation mechanism*. So, a resource allocation mechanism is a (many-one) mapping from initial capital stocks (K_0, S_0) *into* the set of economic programmes $\{C_t, L_t, R_t, K_t, S_t\}_0^\infty$ satisfying equations (A.1)–(A.2).

Let us now formalise this. Write

$$\Omega_t \equiv (K_t, S_t), \text{ and} \tag{A.4}$$

$$(\xi_\tau)_t^\infty \equiv \{C_\tau, L_\tau, R_\tau, K_\tau, S_\tau\}_t^\infty, \text{ for } t \geqslant 0. \tag{A.5}$$

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 (many-one) mapping

$$\alpha: \{t, \Omega_t\} \rightarrow \{(\xi_\tau)_t^\infty\}. \tag{A.6}$$

α would depend on calender time if the knowledge base, or population, or terms of trade were to change autonomously over time.[40] If they were not to display any exogenous shift, α would be independent of t. If α is time-autonomous, then for all τ ($> t$), the economy at τ depends only on Ω_t and ($\tau - t$). We will see presently that, computationally, it is simplest to study cases where α is time-autonomous. So I assume that α does not depend on calendar time (but see Section A.7).

It bears re-emphasis that I do *not* assume α to sustain an optimum economic

---

[40] There are exceptions to this statement in extreme cases, for example, closed economies where production is subject to constant-returns-to-scale, population changes exponentially, technical change is Harrod-neutral, and there are no environmental resources (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 latter are expressed in efficiency units of labour.

programme, nor even 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 $\{C_t(\alpha),\ L_t(\alpha),\ R_t(\alpha),\ K_t(\alpha),\ S_t(\alpha)\}_0^\infty$ denote the forecast at $t = 0$. Consider date $t(\geqslant 0)$. We may now write (A.3) as:

$$V_t(\alpha, \Omega_t) \equiv \int_t^\infty U[\,C_\tau(\alpha),\ L_\tau(\alpha)\,]\,e^{-\delta(\tau - t)}\,d\tau. \tag{A.7}$$

This is social well-being at t.[41]

Institutional assumptions underlie our notion of resource allocation mechanism. Aspects of the concept of 'social capital' (Putnam, 1993) appear in our framework as part of the defining characteristics of α, as do ideas relating to 'social capability' (Adelman and Morris, 1965; Abramovitz, 1986), and 'social infrastructure' (Hall and Jones, 1999). The prevalence (or absence) of trust and honest behaviour in the economy are embodied in α. Other aspects of the concept of social capital (personal networks) enter as factors in the production function F.

The crucial assumption I now make is that V_t is differentiable in each of the two components of Ω. It is not easy to judge if this is a reasonable assumption. The mathematical properties of V_t depend upon the mathematical properties of α. But it is not easy to judge when α is 'smooth'. Problems are compounded because production and substitution possibilities in the economy are embedded in α, as is the economy's underlying institutional structure. Moreover, there are no obvious limits to the kinds of institutions one can envisage. In many parts of the world the State has been known to act in bizarre and horrible ways. 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 about them?

We know that if U is strictly concave and differentiable and the production functions are concave and differentiable, then along optimum economic programmes V_t is differentiable in each of the components of Ω. This is so even in those circumstances where the optimum programme is chaotic. Thus, chaotic αs do not rule out differentiable V_ts.[42] However, if production functions are *not* concave, optimum resource allocation mechanisms can be discontinuous. Skiba (1978) has proved for the case where production functions are S-shaped that at those values of Ω where V_t is non-differentiable (such points are, however, non-generic), V_t is continuous. If, in addition, V_t possesses right- and left-partial derivatives (and it does in the examples I have studied), social cost-benefit analysis of policy reforms can be conducted at the optimum with the aid of accounting prices, using the present discounted value of the flow of social profits as the criterion of choice. The same could be expected to be true for the case of market economies subject to fixed distortions, such as those considered by Dasgupta *et al.* (1972) and Little and Mirrlees (1968, 1974) in their account of social cost-benefit analysis.

Experience with non-linear dynamical systems suggests that if α is *non*-optimal, V_t is discontinuous at certain values of Ω. Accounting prices would not be definable at such points (see equation (A.8) below).[43] However, in those αs that have been studied in the literature, discontinuities would appear to be non-generic. So, unless the economy were by fluke at a point of discontinuity, V_t would be differentiable within a small neighbourhood of the initial capital stocks. It would seem then that the demand that

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

[42] Majumdar *et al.* (2000). I am grateful to Mukul Majumdar for discussions on this.

[43] However, if the location of these points on the space of capital stocks is uncertain and the uncertainty a smooth probability distribution, the *expected value* of V_t would be continuous. I conjecture that in this case accounting prices exist.

V_t be differentiable does not rule out much of practical significance. The theory I offer here is valid for a considerably more general set of environments than is usual in writings on welfare economics.

So I assume, without loss of much generality, that V_t is differentiable.

A.3. *Accounting Prices*

Let the *numeraire* be well-being. Define,

$$p_t(\alpha) \equiv \partial V_t(\alpha, \Omega_t)/\partial K_t; \text{ and } q_t(\alpha) \equiv \partial V_t(\alpha, \Omega_t)/\partial S_t. \qquad \text{(A.8)}$$

From equations (A.7) and (A.8) we have:

$$p_t(\alpha) = \int_t^\infty \{\partial U[C_\tau(\alpha), L_\tau(\alpha)]/\partial K_t\} e^{-\delta(\tau - t)} d\tau, \qquad \text{(A.9a)}$$

and

$$q_t(\alpha) = \int_t^\infty \{\partial U[C_\tau(\alpha), L_\tau(\alpha)]/\partial S_t\} e^{-\delta(\tau - t)} d\tau. \qquad \text{(A.9b)}$$

$p_t(\alpha)$ and $q_t(\alpha)$ are the assets' *accounting prices*. They measure social scarcities of the economy's capital assets. For example, equation (A.9a) says that the accounting price of manufactured capital at t is the present discounted value at t of the flow of marginal welfare if a unit more of the asset were made available at t costlessly. Thus also for the other asset. All future effects on the economy of changes in the structure of assets are reflected in accounting prices. That is why they are useful objects.

Accounting prices are defined in terms of hypothetical perturbations to the economic programme implied by α. In the text, we observed that the structure of property rights influences accounting prices. Accounting prices of 'goods' can be negative if there is a dysfunctional set of property rights, such as those which lead to the tragedy of the commons. Having stressed their functional dependence on α, I drop α from the formulae so as to save on notation.

In principle, accounting prices can be estimated directly from equations (A.9a,b). They can be tracked through time on the basis of the economic forecast conditioned on α. This method is a Platonic ideal and that the 'ideal' is also the method's weakness. So, welfare economists have developed a number of indirect methods for estimating accounting prices.[44]

Recall that $V_t = V_t(\alpha, \Omega_t)$. Suppose that V_t is *not* time-autonomous. Then we may conclude that

$$dV_t/dt = p_t dK_t/dt + q_t dS_t/dt + \partial V_t/\partial t. \qquad \text{(A.10)}$$

If, as we are assuming for the moment, that V_t *is* time-autonomous, equation (A.10) reduces to the more amiable form:

$$dV_t/dt = p_t dK_t/dt + q_t dS_t/dt. \qquad \text{(A.11)}$$

Equations (A.10) and (A.11) are fundamental.

A.4. *Valuation*

By *sustainable development* I mean an economic programme for which $dV_t/dt \geqslant 0$.[45] In the text I said that wealth is the index we should use to check if $dV_t/dt \geqslant 0$. The proof of their equivalence is simple.

---

[44] See Dasgupta (2001) for a review of the methods.
[45] For a justification, see Dasgupta (2001).

Define,

$$I_t^K \equiv p_t \, dK_t/dt \text{ and } I_t^S \equiv q_t \, dS_t/dt, \tag{A.12}$$

which are net investments in the two types of capital assets, respectively, expressed in well-being numeraire. Let us define *genuine investment* to be,

$$I_t = I_t^K + I_t^S. \text{ [46]} \tag{A.13}$$

Now use equations (A.11)–(A.13) to conclude that,

$$dV_t/dt = I_t. \tag{A.14}$$

Equation (A.14) gives us an index of sustainable development:

PROPOSITION 1. *$dV_t/dt \geqslant 0$ if and only if net investment in the economy's capital assets is positive (that is, if and only if there is genuine investment).*[47]

The result has intuitive appeal. It says that social well-being is higher today than it was yesterday if the economy is *wealthier* today. An economy's wealth is the accounting value of all its capital assets. Wealth comparisons are made at constant prices.

Proposition 1 is an *equivalence* result. It cannot by itself tell if sustainable development is feasible. Whether the economy is capable of growing wealthier indefinitely depends, among other things, on the extent to which different assets are substitutable in production. Accounting prices reflect substitution possibilities, among other things.[48]

Imagine that substitution possibilities are limited, and the resource allocation mechanism in place is profligate in the use of natural resources. Then the quality of life will not be sustainable. At some date in the future accounting prices will assume such values as to make it impossible for genuine investment to be positive. Social well-being declines when genuine investment is negative.

What happens to Proposition 1 if population changes over time in an exogenous manner? In that case $\partial V_t/\partial t \neq 0$. From equation (A.10) we conclude that wealth comparisons over time need to be adjusted for demographic differences. $\partial V_t/\partial t$ is the adjustment term. Once that adjustment is made, Proposition 1 remains valid.

A.5. *Evaluation*

Imagine that, even though the government does not optimise, it can bring about small changes to the economy by altering the existing resource allocation mechanism in minor ways for a brief moment. The perturbation in question may, for example, consist of brief adjustments to the prevailing structure of taxes, it could be minor alterations to the existing set of property rights, it could be a public investment, or whatever. Let us call any such perturbation a *policy reform*. I illustrate the theory by considering investment projects.[49]

[46] Note that the summation in equation (A.13) does *not* imply any assumptions regarding substitution possibilities among the two kinds of capital assets. Whatever substitution possibilities there may be would be reflected in the accounting prices.

[47] This result is known to be a property of optimum economic programmes. It originated in Solow (1974, 1992) and Hartwick (1977), in their work on intergenerational maxi-min consumption streams. Dasgupta and Heal (1979, ch. 10) integrated their results with those implied by the Ramsey-Koopmans formulation and offered a finding that was an early version of Proposition 1, but restricted to optimum economic programmes.

[48] Dasgupta and Heal (1979, ch. 7 and 10).

[49] Over the years, economic evaluation of policy reform in an imperfect economy has been discussed by a number of economists (Meade, 1955; Dasgupta *et al.* 1972; Mäler, 1974; Starrett, 1988; Ahmad and Stern, 1990; Dreze and Stern, 1990; and Edwards and Keen, 1996, to name only a few). But they did not develop a formal account of *intertemporal* welfare economics in a reformist economy. Dasgupta and Mäler (2000), whose findings I am reporting here, was an attempt to fill that gap.

Investment projects, if accepted, would be perturbations to the resource allocation mechanism α. I confine myself to projects that are small relative to the size of the economy. How should they be evaluated? Consider a project whose output and inputs at t are denoted by the vector $(\Delta Y_t, \Delta K_t, \Delta L_t, \Delta R_t)$.[50]

The project's acceptance would perturb the aggregate consumption and labour supply under α. Let the perturbation at t be $(\Delta \tilde{C}_t, \Delta \tilde{L}_t)$. It would affect U_t by the amount $(U_C \Delta \tilde{C}_t + U_L \Delta \tilde{L}_t)$. It would be tiresome if the project evaluator was required to estimate $(\Delta \tilde{C}_t, \Delta \tilde{L}_t)$ for every project that came up for consideration. Accounting prices are useful because they enable the evaluator to estimate $(\Delta \tilde{C}_t, \Delta \tilde{C}_t)$ indirectly by estimating the project's social profit.

Let U be chosen as *numeraire*. Recall that the accounting price of manufactured capital is p_t. The corresponding accounting rental rate is δp_t. It is most unlikely that consumption and investment have the same accounting price in an imperfect economy. Therefore, we decompose ΔY_t into three components: consumption and the accumulation of manufactured capital. They can be estimated from α.[51] Denote them as ΔC_t and $\Delta(dK_t/dt)$.

Let w_t denote the accounting wage rate. How would we measure it? If we knew α, we would be able to estimate $\Delta \tilde{L}_t/\Delta L_t$. Now, $w_t = -(\Delta \tilde{L}_t/\Delta L_t) U_L$. So, $w_t = -U_L$ if $\Delta \tilde{L}_t = \Delta L_t$, and $w_t = 0$ if $\Delta \tilde{L}_t = 0$. In 'labour-surplus economies' one would typically find $0 < -(w_t/U_L) < 1$.

It follows that:

$$U_C \Delta \tilde{C}_t + U_L \Delta \tilde{L}_t = U_C \Delta C_t - w_t \Delta L_t + p_t \Delta(dK_t/dt) - \delta p_t \Delta K_t - q_t \Delta R_t. \qquad (A.15)$$

But the right-hand-side (RHS) of equation (A.15) is the project's social profit at t. Let ΔV_0 be the change in social well-being if the project, starting at $t = 0$, were accepted. We then have

$$\Delta V_0 = \int_0^\infty [U_C \Delta C_t - w_t \Delta L_t + p_t \Delta(dK_t/dt) - \delta\, p_t \Delta K_t - q_t \Delta R_t] e^{-\delta t} dt. \qquad (A.16)$$

Equation (A.16) yields the criterion we seek:

PROPOSITION 2. *A project should be accepted if and only if its present discounted value of social profits is positive.*

How is project evaluation related to optimum planning? Imagine that at each date projects are evaluated as a *tatônnement*. The accounting prices used to evaluate projects along the *tatônnement* are those that would prevail if all acceptable projects in the queue to date had been accepted and all unacceptable ones rejected. This sequence of hypothetical choices is often called the 'gradient process' (also called the 'hill-climbing method'). Arrow and Hurwicz (1958) proved in the context of a finite-dimensional economy that, provided the set of economic possibilities has a sufficiently convex structure, the gradient process converges to the optimum. Given that we are considering infinite-dimensional economic programmes, a corresponding result for our model economy would be harder to prove. It is reasonable to conjecture that, despite this, a sequence of project selections in the form of a suitably defined gradient process would converge to an optimum economic programme if the economy had a strong convex structure.[52] If the economy does not have a convex structure, the gradient method can at best be expected to permit the economy to reach a local optimum.

---

[50] If the project has been designed efficiently, we would have $\Delta Y_t = F_K \Delta K_t + F_L \Delta L_t + F_R \Delta R_t$.
[51] See Dasgupta *et al.* (1972) for practical methods of estimation.
[52] In referring to an optimum economic programme, I include 'second-best' optima.

A.6. *Valuation and Evaluation*

How is genuine investment related to the changes in future consumption brought about by it? To answer this, imagine that the capital base at t is not Ω_t, but $\Omega_t + \Delta\Omega_t$, where Δ is an operator signifying a small difference. In the obvious notation:

$$V_t(\alpha, \Omega_t + \Delta\Omega_t) - V_t(\alpha, \Omega_t) \approx \int_t^\infty (U_C\Delta C_\tau + U_L\Delta L_\tau)e^{-\delta(\tau - t)}\, d\tau. \qquad (A.17)$$

Imagine that $\Delta\Omega_t$ is brought about by an increase in genuine investment at t. To see how, we imagine that at t there is a small change in the resource allocation mechanism α, but only for a brief moment, Δt, after which the resource allocation mechanism reverts back to α. We write the increment in the capital base at $t + \Delta t$ consequent upon the brief increase in genuine investment as $\Delta\Omega_t$. So $\Omega_{t+\Delta t} + \Delta\Omega_t$ is the perturbed capital base at $t + \Delta t$. Now let Δt tend to zero. From equation (A.17) we conclude:

PROPOSITION 3: *Genuine investment measures the present discounted value of the changes to consumption services brought about by it.*

Notice the connection between equation (A.17) and equations (A.9a,b). They say the same thing. Proposition 3 brings out the connection between wealth as a measure of social well-being (Proposition 1) and the present discounted value of consumption services as a criterion for social cost-benefit analysis (Proposition 2).

A.7. *Commentary and Extensions*

The economic models developed in this Appendix have important features missing. I comment on a few and show how they can be included.

(1) The distribution of well-being within a generation has been ignored. Theoretically, it is not difficult to include it. If there are M people in each generation and person i consumes C_i, while supplying L_i units of labour, her well-being would be $U(C_i, L_i)$.[53] A simple way to express *intra*generational well-being would be to 'concavify' $U(.)$. Let W be a strictly concave and increasing function defined on real numbers. We may then express intragenerational well-being as $\Sigma_i\{W[U(C_i, L_i)]\}$. Some people would be well-off, others badly-off. The formulation ensures that, at the margin, the well-being of those who are badly off is awarded greater weight than that of someone well-off.

The social worth of the determinants of well-being (C and L) depends on who gets what. To accommodate this idea, we have to enlarge the set of commodities so as to distinguish, at the margin, a good consumed or supplied by one person from that same good consumed or supplied by another. This is the idea of 'named goods'.[54] It 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 someone who is rich. Accounting prices of named goods would depend on the names attached to them. With this re-interpretation of goods and services, the results we have obtained continue to hold.

(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. Accounting prices should be 'named', so as to

---

[53] I have been assuming all along that C_i and L_i are independent of i. Person-specific factors (e.g., age, health status, gender) can be included in the well-being function. This is routinely done in applied economics.

[54] Hahn (1971).

distinguish private costs from social costs and private benefits from social benefits. Pigovian taxes and subsidies on externalities can be computed on the basis of named accounting prices.

(3) In the text, I interpreted natural resources in broad terms. It enabled us to consider a number of issues. 'Resources' were regarded as a 'good' and 'pollutants' (the degrader of resources) a 'bad'. For analytical purposes there is no reason to distinguish resource economics from environmental economics, nor resource management problems from pollution management problems.[55]

Some natural resources have value as a stock, *qua* stock, either because the stock provides a flow of services (ecosystems) or because it has intrinsic value (primates). The way to accommodate this would be to enlarge the domain on which current well-being is defined, by including S. Thus, write $U(C, L, S)$, where $\partial U/\partial S > 0$. The resource's accounting price would reflect this 'stock effect' (equation (A.8)).

Stock pollutants can be introduced in a similar manner. For example, let pollution (carbon emission) be a byproduct of production. Imagine that it is a constant proportion, g, of Y. Let P be the pollutant stock. Assume that it depreciates at a rate π. Then the dynamics of the pollutant would be given by the equation:

$$dP_t/dt = gY_t - \pi P_t.$$

We may write current well-being as $U(C, L, P)$, where $\partial U/\partial P < 0$ and retrace the formal arguments in earlier sections. Accounting prices would include the stock effect of pollutants.

(4) The economy has been assumed to be deterministic. The expected-utility theory continues to be the most compelling one in which to frame the problem of uncertainty and risk. Let social well-being at $t = 0$ be the expected value of the present discounted flow of utility. Now define *contingent goods*, which are goods produced or consumed contingent on identifiable events occuring. From this one can define *contingent accounting prices*. Our analysis would then go through.

(5) I have abstracted from human capital. The way to incoporate it is to define labour in units of effective labour. Someone, whose human capital is H is capable of offering HL units of effective labour if they work L hours. The creation of human capital requires investment (time and resources). If we were to include the formation of human capital in our model, we would specify an accumulation equation for the aggregate stock. The common practice of regarding expenditure in education (e.g. teachers' salaries) as consumption is based on an error: the expenditure is in great part an investment activity.

(6) Models of endogenous technical change abound.[56] Mostly they are not believable as descriptions of substitution possibilities between manufactured capital and natural capital, but they have played a valuable role by emphasising that knowledge is a capital asset, which can be expanded by expenditure in research and development (R&D). Genuine investment includes expenditure in R&D.

(7) The analysis I have provided here is applicable to closed economies. International trade is formally an additional form of production and exchange. International prices are a given if the country in question is small. Price changes should be included in the measure of the country's wealth.[57] Otherwise the analysis remains the same.

Finally, it is as well to remark that this Appendix has been about conceptual matters only. The findings here suggest that the estimation of accounting prices should be a priority. No doubt estimating accounting prices of certain categories of resources will

---

[55] This unification of concerns was explored in Dasgupta (1982).
[56] See Jones (1998).
[57] Sefton and Weale (1996).

prove to be impossible. No single index of social well-being can suffice. Tradeoffs 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 they are unavoidable.

References

Abramovitz, M. (1986), 'Catching up, forging ahead, and falling behind', *Journal of Economic History*, vol. 56, pp. 385–406.

Adelman, I. and Morris, C. T. (1965), 'A factor analysis of the interrelationship between social and political variables and per capita gross national product', *Quarterly Journal of Economics*, vol. 79, pp. 555–78.

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

Arnott, R. and Stiglitz, J. E. (1991), 'Moral hazard and nonmarket institutions: dysfunctional crowding out or peer review?' *American Economic Review*, vol. 81, pp. 179–90.

Arrow, K. J. (1999). 'Observations on social capital', in Dasgupta and. Serageldin (1999)

Arrow, K. J. and Hurwicz, L. (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.

Arrow, K. J. and Kurz, M. (1970). *Public Investment, the Rate of Return and Optimal Fiscal Policy*. Baltimore: Johns Hopkins University Press.

Atkinson, A. B. and Stiglitz, J. E. (1980). *Lectures in Public Economics*. New York: McGraw Hill.

Baland, J.-M. and Platteau, J.-P. (1996). *Halting Degradation of Natural Resources: Is There a Role for Rural Communities*? Oxford: Clarendon Press.

Chichilnisky, G. (1994). 'North-South trade and the global environment', *American Economic Review*, vol. 84, pp. 851–74.

Colchester, M. (1995). 'Sustaining the forests: the community-based approach in South and South-East Asia', *Development and Change*, vol. 25, pp. 69–100.

Cruz, W. and Repetto, R. (1992). *The Environmental Effects of Stabilization and Structural Adjustment Programmes: The Philippines Case*, Washington, D.C.: World Bank?

Daily, G., Dasgupta, P., Bolin, B., Crosson, P., du Guerny, J., Ehrlich, P., Folke, C., Jansson, A.-M., Jansson, B.-O., Kautsky, N., Kinzig, A., Levin, S., Mäler, K.-G., Pinstrup-Andersen, P. and Walker, B. (1998). 'Food production, population growth, and environmental security', *Science*, vol. 281, pp. 1291–2.

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*, vol. 6, pp. 51–67.

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

Dasgupta, P. (1997). 'Environmental and resource economics in the world of the poor', Forty-fifth Anniversary Lecture, Resources for the Future, Washington, D.C.

Dasgupta, P. (1998*a*). 'The economics of poverty in poor countries', *Scandinavian Journal of Economics*, vol. 100, pp. 41–68.

Dasgupta, P. (1998*b*). 'The economics of food', in (J. C. Waterlow, D. G. Armstrong, L. Fowden and R. Riley, eds.), *Feeding a World Population of More than Eight Billion People: A Challenge to Science*, New York: Oxford University Press.

Dasgupta, P. (1999). 'Economic progress and the idea of social capital', in Dasgupta and Serageldin (1999)

Dasgupta, P. (2000). 'Population and resources: an exploration of reproductive and environmental externalities', *Population and Development Review*, vol. 26, pp. 643–689.

Dasgupta, P. (2001). *Human Well-Being and the Natural Environment*. Mimeo., Faculty of Economics, University of Cambridge. Forthcoming, Clarendon Press, Oxford.

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

Dasgupta, P., Kriström, B. and Mäler, K.-G. (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. and Mäler, K.-G. (2000*a*). 'Net national product, wealth, and social well-being', *Environment and Development Economics*, vol. 5, pp. 69–93.

Dasgupta, P. and Mäler, K.-G. (2000*b*). 'Wealth and well-being', Mimeo., Beijer International Institute of Ecological Economics, Stockholm.

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

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

de Soto, H. (2000). *The Mystery of Capital*, New York: Basic Books.

Dollar, D. and Kraay, A. (2000). 'Growth is good for the poor', Discussion Paper, World Bank, Washington, D.C.

Dreze, J. and Stern, N. (1990). 'Policy reform, shadow prices, and market prices', *Journal of Public Economics*, vol. 42, pp. 1–45.

Edwards, J. and Keen, M. (1996). 'Tax competition and Leviathan', *European Economic Review*, vol. 40, pp. 113–34.

Fankhauser, S. (1994). 'Evaluating the social costs of greenhouse gas emissions', *Energy Journal*, vol. 15, pp. 157–84.

Fudenberg and Tirole (1991). Game Theory (Cambridge, MA: MIT Press), pp. 1–579.

Hahn, F. H. (1971). 'Equilibrium with transactions costs', *Econometrica*, vol. 39, pp. 417–40.

Hall, R. E. and Jones, C. I. (1999). 'Why do some countries produce so much more output per worker than others?', *Quarterly Journal of Economics*, vol. 114, pp. 83–116.

Hamilton, K. and Clemens, M. (1999). 'Genuine savings rates in developing countries', *World Bank Economic Review*, vol. 13, pp. 333–56.

Hartwick, J. (1977). 'Intergenerational equity and the investing of rents from exhaustible resources', *American Economic Review*, vol. 66, pp. 972–84.

Hodgson, G. and Dixon, J. (1992). 'Sedimentation damage to marine resources: environmental and economic analysis', in (J. B. Marsh, ed.), *Resources and Environment in Asia's Marine Sector*, London: Taylor & Francis.

Hoff, K., Braverman, A. and Stiglitz, J. E. eds. (1993). *The Economics of Rural Organizations: Theory, Practice and Policy*, New York: Oxford University Press.

Hussain, A., Stern, N. and Stiglitz, J. (2000). 'Chinese reforms from a comparative perspective', in (P. J. Hammond and G. D. Myles, eds.), *Incentives, Organization, and Public Economics*, Oxford: Oxford University Press.

Jones, C. I. (1998). *Introduction to Economic Growth*, New York: W. W. Norton.

Little, I. M. D. and Mirrlees, J. A. (1968). *Manual of Industrial Project Analysis in Developing Countries: Social Cost Benefit Analysis*, Paris: OECD.

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

Luce, R. D. and Raiffa, H. (1957). *Games and Decisions*, New York: John Wiley.

Lutz, E., ed. (1993). *Toward Improved Accounting for the Environment*, Washington, DC: World Bank.

Majumdar, M., Mitra, T. and Nishimura, K. eds. (2000). *Optimization and Chaos*, Berlin: Springer-Verlag.

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

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

Meade, J. E. (1989). *Agathotopia: The Economics of Partnership*, Aberdeen: University of Aberdeen Press.

Mirrlees, J. A. (1967). 'Optimum growth when the technology is changing', *Review of Economic Studies*, vol. 34 (Symposium Issue), pp. 95–124.

Myles, G. D. (1995). *Public Economics*, Cambridge: Cambridge University Press.

Narayan, D. and Pritchett, L. (1999). 'Cents and sociability: household income and social capital in rural Tanzania', *Economic Development and Cultural Change*, vol. 47, pp. 871–89.

Nash, J. (1950). 'The bargaining problem', *Econometrica*, vol. 18, pp. 155–62.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*, Cambridge: Cambridge University Press.

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*), pp. 34.

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

Reed, D., ed. (1996). *Structural Adjustment, the Environment and Sustainable Development*, London: Earth-scan.

Sefton, J. and Weale, M. (1996). 'The net national product and exhaustible resources: the effects of foreign trade', *Journal of Public Economics*, vol. 61, pp. 21–48.

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.

Seymour, F. J. and Dubash, N. K. (2000). *The Right Conditions: The World Bank, Structural Adjustment, and Forest Policy Reform*, Washington, D.C.: World Resources Institute.

Skiba, A. K. (1978). 'Optimal growth with a convex-concave production function', *Econometrica*, vol. 46, pp. 527–40.

Solow, R. M. (1974). 'Intergenerational equity and exhaustible resources', *Review of Economic Studies*, vol. 41 (Symposium Issue), pp. 29–45.

Solow, R. M. (1992). 'An almost practical step toward sustainability', 40th Anniversary Lecture, Resources for the Future, Washington, D.C.

Solow, R. M. (1999). 'Notes on social capital and economic performance', in (P. Dasgupta and I. Serageldin, eds.), *Social Capital: A Multifaceted Perspective*, Washington, D.C.: World Bank.

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

Udry, C. (1993). 'Credit markets in Northern Nigeria: credit as insurance in a rural economy', in Hoff *et al.* (1993),

Udry, C. (1994). 'Risk and insurance in a rural credit market: an empirical investigation in Northern Nigeria', *Review of Economic Studies*, vol. 61, pp. 495–526.

UNDP (United Nations Development Programme) (1995). *Human Development Report*, New York: Oxford University Press.

Wade, R. (1988). *Village Republics: Economic Conditions for Collective Action in South India*, Cambridge: Cambridge University Press.

World Bank (1997). *Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development*, Washington, D.C.: World Bank.