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ENVIRONMENT DEPARTMENT PAPERS

PAPER NO. 77

TOWARD ENVIRONMENTALLY AND SOCIALLY SUSTAINABLE DEVELOPMENT

ENVIRONMENTAL ECONOMICS SERIES

Genuine Saving as a Sustainability Indicator

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October 2000

The World Bank

THE WORLD BANK ENVIRONMENT DEPARTMENT

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Introduction

The publication of the Brundtland Commission report in 1987 introduced a critical new dimension to our conception of economic development by raising the issue of the *sustainability* of development. While definitions of sustainable development abound (Pezzey 1989 is a good summary), economists have settled on a simple formulation that can capture a very rich set of phenomena: a development path is sustainable if total welfare does not decline along the path. As long as the welfare function is sufficiently expansive in what it measures (consumption, environmental quality, social equity, and other factors contributing to the quality of life), this definition permits a rigorous characterization of sustainable development.

Pearce and others (1989) take the sustainability argument one step farther by positing the existence of critical natural capital (the ozone layer, for instance) for which no substitutes exist. This conception of *strong* sustainability therefore requires the preservation of critical natural capital in order for development to be sustainable. *Weak* sustainability assumes that there are substitutes for all assets.

As should be obvious, opting for sustainability is an ethical decision. The Utilitarian maximand assumed in most models of economic growth, the present value of welfare along the optimal path, can be shown to lead to unsustainable outcomes under simple assumptions (fixed technology and pure rate of time preference combined with an exhaustible resource that is essential for production—see Dasgupta and Heal 1979). Choosing sustainability implies a concern with the welfare of future generations that is not captured by the Utilitarian maximand. The fact that most countries and international institutions have adopted sustainable development as an explicit goal suggests that a powerful impulse is at work.

The question of sustainability is particularly stark for an extractive economy reliant upon exhaustible resources. Economists posed the question of sustainability in somewhat different words at the time of the first oil crisis of the 1970's: would economies that depend upon an exhaustible resource inevitably decline as the resource is depleted? An early paper on this topic by Solow (1974) spurred Hartwick (1977) to provide a simple answer to this question. If the "Hartwick rule" is followed, so that investment in produced capital just equals current scarcity rents on the exhaustible resource at each point in time, then the resulting path for the economy is one where welfare equals a maximal constant value *ad infinitum*—in other words, this is a sustainable economy. This holds even for a fixed technology. Hamilton (1995) explores the critical role that the elasticity of substitution between produced assets and natural resources plays in the feasibility of the Hartwick path.

However it may be defined in detail, achieving sustainable development necessarily entails creating and maintaining wealth. Given the centrality of savings and investment in economic theory, it is perhaps surprising that the effects of depleting natural resources and degrading the environment have not, until recently, been considered in the measurement of national savings. Augmented measures of savings and wealth in the national accounts offer promise, therefore, as indicators of sustainable development, which was a prime motivation for the publication of *Expanding the Measure of Wealth* (World Bank 1997). The first cross-country application of these greener accounting methods to the measurement of net savings appeared in Pearce and Atkinson (1993), who combined published estimates of depletion and degradation for 20 countries with standard national accounting data to examine true savings behaviour. By this measure many countries appear to be unsustainable because their gross savings are less than the combined sum of conventional capital depreciation and natural resource depletion.

The indicator of sustainability developed below is termed "genuine saving," to distinguish it from the usual national accounts definitions of saving. Not surprisingly, the definition of this measure hinges on a fundamental question: what is income? This note will develop a theoretical approach to measuring whether an economy is on a sustainable path, and then present empirical evidence on the sustainability of a range of economies.

Genuine Saving—A Formal Model

The notion of genuine saving was presented briefly and informally in Hamilton (1994) and Pearce *et al.* (1996). This section provides a more rigorous development of these ideas, using a model that, while extremely simple, serves to identify the adjustments needed to savings measures in order to account for natural resources, pollutants and human capital.

We assume a simple closed economy with a single resource used as an input to the production of a composite good that may be consumed, invested in produced assets or human capital, or used to abate pollution, so that $F(K,R,N) = C + \dot{K} + a + m$, where R is resource use, a is pollution abatement expenditures, N is human capital, and m is investment in human capital (current education expenditures). Function $q(m)$ transforms education expenditures into human capital that does not depreciate (it can be considered to be a form of disembodied knowledge), so that $\dot{N} = q(m)$ [1]. Labour is fixed and is therefore factored out of the production function.

Pollution emissions are a function of production and abatement, $e = e(F,a)$, and pollutants accumulate in a stock X such that $\dot{X} = e - d(X)$, where d is the quantity of natural dissipation of the pollution stock. The flow of environmental services B is negatively related to the size of the pollution stock, so that $B = \alpha(X)$, $\alpha_X < 0$. Resource stocks S grow by an amount g and are depleted by extraction R, so that $\dot{S} = -R + g(S)$, and resources are assumed to be costless to produce. The utility of consumers is assumed to be a function of consumption and environmental services, $U = U(C,B)$. There is a fixed pure rate of time preference r.

Following Hartwick (1990), new 'green' national accounting aggregates are defined on the basis of an intertemporal optimization problem. Wealth W is defined to be the present value of utility on the optimal path. It is assumed that a social planner wishes to maximize wealth as follows,

$$\max\ W = \int_t^{\infty} U(C,B)e^{-rs}ds \quad \text{subject to:}$$

$$\dot{K} = F - C - a - m$$

$$\dot{X} = e - d$$

$$\dot{S} = -R + g$$

$$\dot{N} = q(m)$$

The current value Hamiltonian function, which is maximized at each point in time, is given by,

$$H = U + \gamma_K \dot{K} + \gamma_X \dot{X} + \gamma_S \dot{S} + \gamma_N \dot{N}, \qquad (1)$$

where γ_K, γ_X, γ_S, and γ_N are respectively the shadow prices in utils of capital, pollution, resources and human capital. Deriving the static first-order conditions for a maximum, the Hamiltonian function may be written as,

$$H = U(C,B) + U_C\big(\dot{K} - (1 - be_F)F_R(R-g) - b(e-d) + q/q'\big).$$

Note that b is the marginal cost of pollution abatement. It is shown in Hamilton (1996) that this is precisely equal to the marginal social cost of pollution emissions, and that this in turn is equal to the level of a tax—the Pigovian tax required to maximize welfare—on emissions. These equalities hold because the economy is at the optimum. The term be_F is the effective tax rate on production as a result of the emissions tax. Therefore, although we have started with an optimal growth problem, the prices that result are those that would prevail in a competitive economy with a Pigovian tax on pollution. Note as well that $1/q'$ is the marginal cost of creating a unit of human capital.

Since $\dot{S} = -R + g$, $\dot{X} = e - d$ and $\dot{N} = q$, the parenthesized expression in the second term of this expression is equal to the change in the real value of assets in this simple economy, where human capital is valued at its marginal creation cost, pollution stocks are valued at marginal abatement costs and natural resources at the resource rental rate, F_R, net of the effective tax rate on production associated with pollution emissions. This expression serves to define genuine saving, G,

$$G \equiv \dot{K} - (1 - be_F)F_R(R-g) - b(e-d) + q/q'. \qquad (2)$$

For non-living resources the term in growth g can be dropped from expression (2), while for cumulative pollutants the term in dissipation d can be discarded.

Genuine saving consists therefore of investment in produced assets and human capital, less the value of depletion of natural resources and the value of accumulation of pollutants. It is straightforward to show that,

$$U_C G = \dot{W} = rW - U. \qquad (3)$$

Expression (3) entails the following property: measuring negative genuine saving at a point in time implies that future utility is less than current utility over some period of time on the optimal path. Negative genuine saving therefore serves as an indicator of non-sustainability.

This expression also implies that Hicksian income, the maximum amount of produced output that could be consumed while leaving total wealth instantaneously constant, is given by,

$$NNP = C + \dot{K} - (1 - be_F)F_R(R-g) - b(e-d) + q/q'. \qquad (4)$$

Hamilton and others (1998) argue that policy distortions in a typical economy lead to over-extraction of natural resources and excess pollution emissions. Under these conditions it can be shown that current resource rents exceed their optimal level, as do marginal pollution damages. More optimal resource and environmental policies will reduce this bias and also increase genuine savings.

The current model can easily be extended to include foreign trade and depreciation of produced assets. If produced capital depreciates at a percentage rate equal to δ, then the accounting identity for these assets becomes,

$$\dot{K} = F - C - a - m - \delta K.$$

Turning to foreign trade, net foreign assets A accumulate as a result of exports E, and decumulate with imports M. For a fixed international rate of return i, therefore, the asset accounting identity is,

$$\dot{A} = iA + E - M .$$

With these added assumptions the measure of NNP (derived, as above, as extended Hicksian income) for an open economy is given by,

$$NNP = C + \dot{K} - \delta K + E - M + iA \\ - (1 - be_F)F_R(R - g) - b(e - d) + q / q' .$$

The first six terms in this expression are precisely the standard measure of NNP. Expanding the asset base implies that standard NNP should be adjusted by deducting net depletion of natural resources and the marginal damages from net pollution accumulation, and by adding investments in human capital.

The treatment of current education expenditures and pollution abatement expenditures requires more elaboration. Hamilton (1994) essentially argues that current education expenditures are not consumption, and therefore should be included in saving. Defining net marginal resource rents as $n \equiv (1 - be_F)F_R$, NNP be can be defined as,

$$\begin{aligned} NNP &= GNP - a - m - n(R - g) - b(e - d) + q / q' \\ &= GNP - a - n(R - g) - b(e - d) + \left(\frac{1/q'}{m/q} - 1 \right) m \end{aligned} \tag{5}$$

where $1 / q'$ is the marginal cost of creating a unit of human capital and m / q is the average cost. Assuming increasing marginal education costs, expression (5) suggests that the value of investments in human capital should be greater than current education expenditures—these current expenditures can therefore serve as a lower-bound estimate of the investment in human capital.

Expression (5) says that pollution abatement expenditures a are essentially intermediate in character and should be deducted in measuring genuine saving. In practice, most current abatement expenditures are already treated as intermediate inputs in standard national accounting.

Finally, it is important to present the formula for calculating genuine saving from real data. For produced asset depreciation δK, net resource rental rate n, and marginal social cost of pollution σ this is given by,

$$G = GNP - C - \delta K - n(R - g) - \sigma(e - d) + m. \tag{6}$$

Here $GNP - C$ is traditional gross saving, which includes foreign savings, while $GNP - C - \delta K$ is traditional net saving. Similarly, since carbon dioxide is the only pollutant considered in what follows, the adjustment to net resource rents $(1 - be_F)$ can safely be assumed to be near 1, while dissipation d is assumed to be small relative to emissions e[2].

Net natural growth of living resources $(R - g)$ is not added to genuine savings when it is positive, but net depletion (that is when $R > g$) is deducted. While this will bias the results against sustainability, Vitousek and others (1986) estimate that less than 33 percent of standing forests are merchantable. Subtracting only net depletion of forests ensures that the growth of uneconomic forest resources is not counted as an addition to income.

Coverage and Calculation Issues

The list of data sources for the resource rental estimates are given in Hamilton and Clemens (1999). The basic approach to calculating resource rents for non-renewable resources is to subtract country- or region-specific average costs of extraction from the world price for the resource in question, all expressed in current US dollars. Many world prices were derived from World Bank commodity data—where multiple markets, for example London and New York, are reported, a simple average of these market prices serves as the world price.

For minerals the levels of total resource rents are thus calculated as:

Rent = World price - mining cost
- milling and beneficiation costs
- smelting costs - transport to port
- 'normal' return to capital.

For crude oil, unit rents are calculated as the world price less lifting costs. Natural gas, though its international trade has soared in recent years, does not have a single world price. A world price was estimated by averaging free-on-board prices from several points of export worldwide, following which the unit rents were calculated as for oil.

There are several further points to note about this methodology:

- Countries may or may not be selling their natural resources for internal consumption at the world market price, although one would expect that they have every incentive to do so. Moreover, the use of uniform world prices will tend to overstate rents for countries with lower-grade resources.

- Extraction costs are measured at a fixed point in time, a point which differs from country to country and resource to resource according to data availability, and held constant in real terms. World prices vary over time, leading to corresponding variations in calculated rental rates.

- Where the extraction cost data were region- rather than country-specific, the regional cost structure was applied to all of the producing countries in the region.

The total rent estimates used in this note are therefore fairly crude. In compensation, the estimates are calculated using a uniform methodology and the coverage is quite wide. In addition to timber, coal, oil and natural gas, the minerals covered include zinc, iron ore, phosphate rock, bauxite, copper, tin, lead, nickel, gold, and silver. Data problems led to the exclusion of diamonds from these estimates.

Resource depletion is assumed to be equal to total resource rents, an application of the "net price" method of depletion estimation (Repetto and others 1989). This arguably over-estimates the value of resource depletion, particularly for countries having large reserves to production ratios. Where this estimation method could significantly influence the empirical results it is noted below.

Turning to pollution damages, these should ideally reflect emissions and exposure data for the full range of local, regional and global pollutants. In practice, there are no comprehensive data on local and regional pollutants. As a "place-holder" for other pollutants, therefore, damages from carbon dioxide emissions are included in the genuine saving calculation, using a figure of $20 per ton of carbon derived from Fankhauser (1995) and widely available data on CO_2 emissions from industrial sources. Making a deduction for emissions of a global pollutant is conceptually correct if certain property rights are assumed, in particular the right not to be damaged by your neighbour's pollution emissions.

Education expenditure data are from UNESCO (1998).

Results

Country-level results for genuine saving and its components in 1997 are presented in Table A1.

As this table indicates, negative genuine saving is more than a theoretical possibility. It is important to note several issues with regard to these figures. First, a point measure of genuine saving does not necessarily imply that the country in question is fated for an unsustainable development path; it does imply, however, that continuing the current policy mix is unsustainable. Second, it may be perfectly rational for either extremely poor or extremely rich countries to consume wealth in the short run, in the former case to hold off starvation, in the latter because consuming a very small proportion of wealth entails a low loss of welfare over time. Finally, negative genuine savings rates represent an opportunity not taken: resource endowments represent a type of stored development finance, and some countries choose not to benefit from this natural advantage.

Broad trends in the savings figures can be seen in Table 1, which summarizes genuine savings for regional and income-level aggregations of countries.

Comparing low and middle income countries in Table 1, the 10.2 percent difference in genuine savings is largely explained by a 9.2 percent difference in the gross saving rate. However, depletion is significantly higher in low income countries, at 6.6 percent of GDP as compared with 4.5 percent in middle income. Much of this difference in turn is a function of the 1.8 percent of GDP that net forest depletion represents in low income countries. In high-income countries, depletion is only 0.5 percent of GDP and

Table 1. Genuine saving as percent of GDP, 1997

	Gross domestic savings	*Consumption of fixed capital*	*Net domestic savings*	*Education expenditure*	*Energy depletion*	*Mineral depletion*	*Net forest depletion*	*Carbon dioxide damage*	*Genuine domestic savings*
World	22.2	11.7	10.5	5.0	1.2	0.1	0.1	0.4	13.6
Low income	17.0	8.0	9.1	3.4	4.2	0.6	1.8	1.2	4.8
Middle income	26.2	9.2	17.0	3.5	3.8	0.5	0.2	1.1	15.0
High income	21.4	12.4	9.0	5.3	0.5	0.0	0.0	0.3	13.5
East Asia & Pacific	38.3	6.9	31.4	2.1	0.9	0.5	0.7	1.7	29.7
Europe & Central Asia	21.4	13.7	7.9	4.2	4.9	0.1	0.0	1.6	5.6
Latin America & Carib.	20.5	8.3	12.2	3.6	2.7	0.7	0.0	0.3	12.1
Middle East & N. Africa	24.1	8.8	15.3	5.2	19.7	0.1	0.0	0.9	-0.3
South Asia	18.2	9.1	9.1	3.8	2.1	0.4	2.0	1.3	7.1
Sub-Saharan Africa	16.8	9.1	7.8	4.5	5.9	1.4	0.5	0.9	3.4

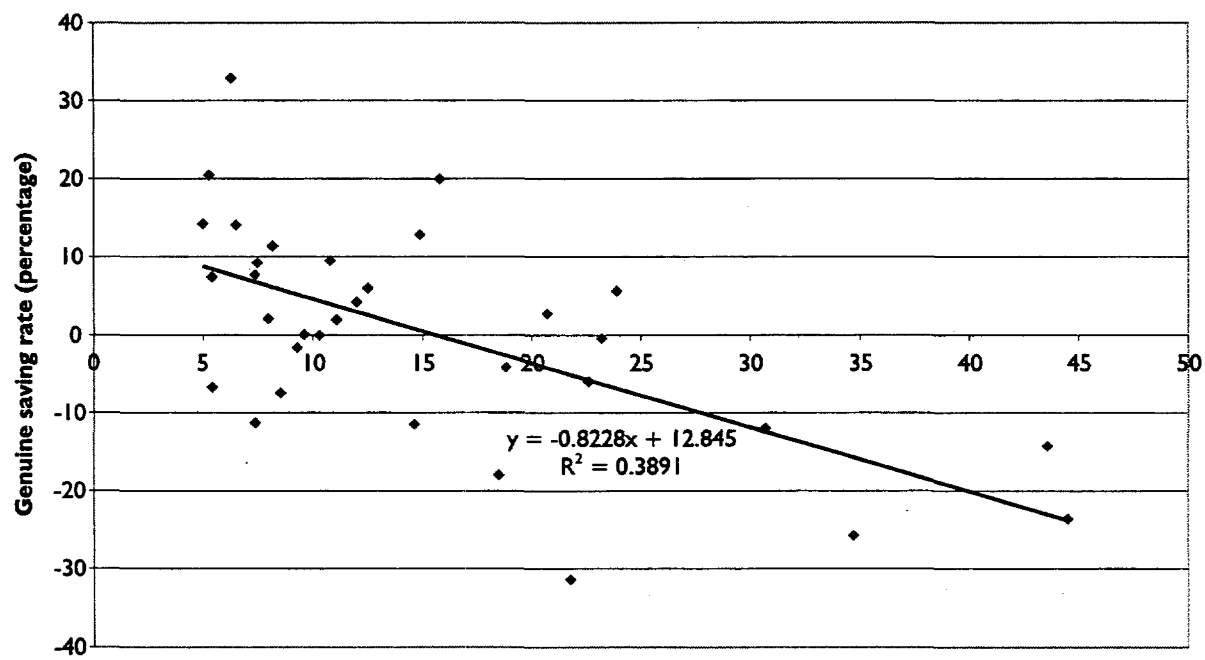
education expenditures are 2 percent higher than in low and middle income countries.

Turning to regional comparisons, East Asia and the Pacific exhibits high gross and genuine savings rates, with depletion amounting to 2.1 percent. As the events of 1997/98 have made clear, however, high savings rates are not synonymous with financial and macroeconomic stability, however advantageous they may be for rapid wealth accumulation. In Latin America and the Caribbean the average genuine saving effort is fairly robust, although this masks some individual examples of poor performance as in the case of Venezuela. Other regions exhibit a weak genuine saving effort, particularly in the oil states of the Middle East and North Africa,[3] and in Sub-Saharan Africa where depletion is a substantial 7.8 percent of GDP.

More insight into 1997 genuine savings rates is provided by Figure 1, which scatters the genuine saving rate for the most resource dependent countries (those where depletion exceeds 5 percent of GDP) against the share of depletion in GDP. As the regression equation next to the fitted line shows, there is a weak tendency ($R^2 = 0.389$) for increasing depletion shares of GDP to be associated with lower genuine savings rates. The regression coefficients are significant ($t = -4.44$ and 3.75 for the slope and the constant respectively). The slope of the regression line can be interpreted as an elasticity, and therefore says that each 1 percent rise in the depletion share of GDP is associated with a 0.82 percent decline in the genuine saving rate.

This slope can also be interpreted as the marginal propensity to consume resource rents, although it must be kept in mind that the slope is derived from cross-sectional data. It says that there is a tendency, looking across countries, for 82 percent of each increment in resource rents as a share of GDP to be consumed. If in each

Figure 1. Genuine saving rate versus depletion share of GDP in resource-dependent economies, 1997



country all resource rents were invested rather than consumed then no statistically significant tendency would be visible in Figure 1—an extra unit of resource rent in GDP would have no effect on genuine savings, other things being equal.

This interpretation of the regression results must be tempered by recalling that the countries with largest depletion share of GDP (those in the lower right of Figure 1) tend also to be those with the largest resource endowments, and so the total rent approach to measuring depletion may be influencing the results derived.

Policy Issues

It is abundantly clear that monetary and fiscal policies are the biggest levers for boosting savings rates. The first policy issue is therefore a classic macroeconomic one: to what extent do monetary and fiscal policies encourage strong domestic savings?

While natural resource exports boost foreign savings and therefore the overall savings effort, the analysis of genuine savings suggests a further question: to what extent do exports of *exhaustible* resources boost the genuine rate of saving?[4] The answer to this lies in netting out the value of resource depletion from gross export values.

More optimal natural resource extraction paths will, other things being equal, boost the value of genuine savings. The policy question for natural resource management is therefore: to what extent can stronger resource policies (royalty regimes, tenure) boost the genuine rate of saving?

Similarly, reducing pollution emissions to socially optimal levels will boost the value of genuine savings. The policy issue with respect to pollution is: to what extent can more optimal pollution control policies increase the rate of genuine saving?

Note that the policy prescriptions for boosting genuine savings should never be to stop extracting resources or emitting pollutants altogether. Rather, pricing resources and pollutants correctly and enforcing property rights will lead to efficient levels of exploitation of the environment, reducing incentives to 'high-grade' resources or pollute indiscriminately. Optimal resource and environmental policies will maximize genuine savings, subject to the macroeconomic policy regime in place. However, the sorts of issues raised by Gelb (1988) about the nature and effects of oil windfalls in developing countries are particularly relevant to the policy issues just raised: without sound macroeconomic policies and prudent allocation of public resources, the effects of reliance upon large resource endowments can be negative for many countries.

Conclusions

Growth theory provides the intellectual underpinning for expanded national accounting and, through the measure of genuine saving, an indicator of when economies are on an unsustainable development path. This theory points in useful directions for countries concerned with sustainable development.

Far from being a mere theoretical possibility, there is abundant evidence for countries whose policy mix results in negative genuine saving rates. While the latest World Bank estimates for 1997 are emphasized here, previous studies such as Hamilton and Clemens (1999) and Atkinson and others (1997) have shown this to be true over decades as well.

The evidence suggests that, while resource-dependent economies are potentially sustainable if resource rents are invested in other productive assets (including human capital), many of these economies have not chosen this path. The results presented here show distinctive patterns of genuine savings across regions and country income groups.

However, as the example of Southeast Asia in 1997/98 shows, robust genuine savings do not necessarily lead to a smooth development path. Some of the broader lessons from the financial crisis in Southeast Asia concern the rates of return that were achieved with these savings—many investments were yielding zero or exceedingly small returns. So the lessons to be drawn from the analysis of genuine saving must go beyond the level of saving to a concern with the quality of the investments that are made with these savings.

The genuine savings analysis raises an important set of policy questions that goes beyond the traditional concern with the macro and microeconomic determinants of savings effort. The questions of rent capture, public investments of resource revenues, resource tenure policies, and the social costs of pollution emissions are equally germane in determining the overall level of saving, although it is clear that monetary and fiscal policy remain the big levers.

This analysis also provides a practical way for natural resource and environmental issues to be discussed in the language that ministries of Finance understand. This may prove to be an important advantage as many resource-dependent economies struggle to achieve their development goals.

Table A1. Genuine saving and its components as percent of GDP, 1997

	Gross domestic savings	*Consumption of fixed capital*	*Net domestic savings*	*Education expenditure*	*Energy depletion*	*Mineral depletion*	*Net forest depletion*	*Carbon dioxide damage*	*Genuine domestic savings*
Albania	-13.2	12.4	-25.6	2.8	0.0	0.1	0.0	0.5	-23.5
Algeria	34.5	9.3	25.2	6.3	2.4	0.1	0.0	1.1	27.9
Angola	27.3	6.0	21.2	2.6	20.7	0.0	0.0	0.4	2.7
Argentina	18.4	10.5	7.9	2.4	0.5	0.0	0.0	0.2	9.6
Armenia	-28.8	..	..	0.0	0.0	0.0	0.0	1.3	..
Australia	20.7	14.6	6.1	4.7	1.2	1.5	0.0	0.4	7.6
Austria	23.5	12.9	10.5	4.9	0.1	0.0	0.0	0.1	15.2
Azerbaijan	9.5	14.0	-4.5	0.0	21.8	0.0	0.0	5.1	-31.4
Bangladesh	14.7	7.2	7.5	2.1	0.2	0.0	0.0	0.3	9.1
Belarus	21.6	17.2	4.4	4.7	0.0	0.0	0.0	1.7	7.4
Belgium	22.3	10.1	12.2	4.9	0.0	0.0	0.0	0.2	16.9
Benin	10.8	5.4	5.4	0.0	0.0	0.0	0.0	0.2	5.2
Bolivia	10.1	8.1	2.0	2.6	0.9	1.1	0.0	0.7	1.8
Bosnia and Herzegovina	..	..	..	..	0.0	0.0	0.0	..	..
Botswana	44.7	13.3	31.4	6.9	0.0	0.8	0.0	0.3	37.2
Brazil	18.6	7.5	11.1	4.2	0.6	0.7	0.0	0.2	13.9
Bulgaria	17.4	10.1	7.3	4.0	0.5	1.3	0.0	2.7	6.7
Burkina Faso	9.2	4.6	4.6	2.8	0.0	0.0	0.0	0.2	7.1
Burundi	2.6	4.4	-1.8	3.0	0.0	0.0	8.5	0.1	-7.4
Cambodia	4.2	5.0	-0.8	0.0	0.0	0.0	0.0	0.1	-0.9
Cameroon	20.6	7.5	13.1	2.3	7.4	0.0	0.0	0.3	7.7
Canada	21.5	12.5	9.0	6.1	1.5	0.4	0.0	0.4	12.8
Central African Republic	6.7	5.2	1.5	3.8	0.0	0.0	0.0	0.1	5.1
Chad	1.2	4.6	-3.4	0.0	0.0	0.0	0.0	0.0	-3.5
Chile	24.5	6.8	17.7	3.2	0.1	6.4	0.0	0.4	14.1
China	42.7	6.2	36.5	1.9	0.0	0.5	0.6	2.4	34.9
Hong Kong, China	30.6	..	..	2.0	0.0	0.0	0.0	0.1	..
Colombia	15.8	6.5	9.4	2.8	4.4	0.1	0.0	0.4	7.3
Congo, Dem. Rep.	9.0	5.0	4.0	0.7	0.0	0.6	0.0	0.2	3.8
Congo, Rep.	34.8	9.2	25.6	4.3	23.9	0.0	0.0	0.4	5.6
Costa Rica	25.0	2.5	22.5	4.6	0.0	0.0	0.0	0.3	26.8
Côte d'Ivoire	23.1	7.0	16.0	5.7	1.5	0.0	0.0	0.7	19.6
Croatia	3.3	9.2	-5.9	0.0	0.9	0.0	0.0	0.5	-7.3
Cuba	..	..	..	..	0.0	0.0	0.0	..	..
Czech Republic	28.4	17.2	11.2	5.3	0.4	0.0	0.0	1.3	14.8
Denmark	..	15.3	..	7.7	0.4	0.0	0.0	0.2	..
Dominican Republic	22.1	5.9	16.1	1.2	0.0	0.5	0.0	0.8	16.0
Ecuador	21.2	6.9	14.2	2.7	12.0	0.0	0.0	0.7	4.2
Egypt, Arab Rep.	13.0	7.9	5.1	4.8	3.2	0.1	0.0	0.7	5.9
El Salvador	4.5	6.1	-1.6	2.2	0.0	0.0	2.0	0.3	-1.6
Eritrea	-17.4	4.1	-21.5	..	0.0	0.0	0.0	..	..
Estonia	18.4	10.5	7.9	4.3	1.7	0.0	0.0	2.3	8.2
Ethiopia	8.7	..	..	2.9	0.0	0.0	0.0	0.3	..
Finland	24.6	16.7	7.9	7.2	0.0	0.0	0.0	0.2	14.8
France	19.7	12.9	6.8	5.0	0.0	0.0	0.0	0.1	11.6
Gabon	48.3	15.2	33.1	3.1	15.8	0.0	0.0	0.4	20.0
Gambia, The	3.8	12.3	-8.6	3.3	0.0	0.0	0.0	0.3	-5.6
Georgia	-3.7	..	..	0.0	0.0	0.0	0.0	0.9	..
Germany	22.4	13.2	9.2	4.4	0.1	0.0	0.0	0.2	13.4
Ghana	9.8	4.3	5.5	2.4	0.0	2.5	0.0	0.4	5.0
Greece	..	8.5	..	..	0.0	0.0	0.0	..	..
Guatemala	8.1	6.0	2.1	2.1	0.6	0.0	2.0	0.2	1.4
Guinea	18.7	6.1	12.6	2.3	0.0	18.8	0.0	0.2	-4.1
Guinea-Bissau	5.0	4.8	0.3	1.8	0.0	0.0	0.0	0.5	1.5
Haiti	-4.5	1.5	-6.0	2.3	0.0	0.0	7.4	0.1	-11.3
Honduras	21.8	6.0	15.8	3.7	0.0	0.2	0.0	0.4	18.8
Hungary	26.9	8.0	18.9	5.2	0.4	0.1	0.0	0.7	23.0
India	20.0	10.0	10.0	4.3	2.6	0.5	2.3	1.6	7.4
Indonesia	30.6	5.0	25.6	0.9	3.8	0.8	0.7	0.9	20.5
Iran, Islamic Rep.	..	15.3	..	..	0.0	0.0	0.0	..	..
Iraq	..	9.0	..	..	0.0	0.0	0.0	..	..
Ireland	33.1	9.2	23.9	5.1	0.0	0.1	0.0	0.3	28.7
Israel	8.7	13.8	-5.1	6.7	0.0	0.1	0.0	0.3	1.3

	Gross domestic savings	Consumption of fixed capital	Net domestic savings	Education expenditure	Energy depletion	Mineral depletion	Net forest depletion	Carbon dioxide damage	Genuine domestic savings
Italy	22.3	12.4	9.9	4.2	0.1	0.0	0.0	0.2	13.9
Jamaica	21.6	6.4	15.2	4.4	0.0	12.5	0.0	1.1	6.0
Japan	30.5	15.8	14.6	5.8	0.0	0.0	0.0	0.1	20.3
Jordan	5.5	9.7	-4.2	3.4	0.0	1.2	0.0	1.1	-3.1
Kazakhstan	13.5	7.4	6.1	0.0	18.5	0.0	0.0	5.5	-17.9
Kenya	11.4	6.7	4.7	5.9	0.0	0.0	8.0	0.4	2.1
Korea, Dem. Rep.	..	..	..	..	0.0	0.0	0.0	..	..
Korea, Rep.	34.2	10.0	24.3	3.0	0.0	0.0	0.0	0.5	26.7
Kuwait	25.2	8.6	16.6	4.3	44.5	0.0	0.0	..	-23.6
Kyrgyz Republic	13.8	10.2	3.6	4.3	0.6	0.0	0.0	2.3	5.0
Lao PDR	11.4	5.5	5.8	1.8	0.0	1.4	0.0	0.1	6.2
Latvia	9.6	11.7	-2.1	6.5	0.0	0.0	0.0	1.2	3.1
Lebanon	-16.7	8.7	-25.5	1.5	0.0	0.0	0.1	0.5	-24.5
Lesotho	-9.8	8.3	-18.1	4.8	0.0	0.0	0.0	..	-13.3
Libya	..	..	..	..	0.0	0.0	0.0	..	..
Lithuania	16.0	7.1	8.9	4.4	0.0	0.0	0.0	1.0	12.3
Macedonia, FYR	3.5	..	..	5.7	0.0	0.0	0.0	..	..
Madagascar	3.6	4.9	-1.3	2.3	0.0	0.0	0.0	0.2	0.8
Malawi	2.1	6.4	-4.3	3.2	0.0	0.0	5.4	0.2	-6.7
Malaysia	44.4	9.3	35.1	4.8	4.1	0.1	2.1	0.7	32.9
Mali	13.6	5.8	7.8	2.8	0.0	0.0	0.0	0.1	10.5
Mauritania	8.5	8.6	-0.1	4.9	0.0	14.6	0.0	1.7	-11.5
Mauritius	24.1	7.7	16.4	3.1	0.0	0.0	0.0	0.2	19.3
Mexico	26.4	10.4	16.0	3.7	4.8	0.2	0.0	0.5	14.2
Moldova	0.3	..	..	5.0	0.0	0.0	0.0	2.8	..
Mongolia	17.5	7.6	9.9	5.9	0.0	9.6	0.0	6.2	0.1
Morocco	16.8	7.7	9.1	4.7	0.0	0.4	0.0	0.5	13.0
Mozambique	13.6	3.6	10.0	3.9	0.0	0.0	3.7	0.2	9.9
Myanmar	..	2.8	..	..	0.0	0.0	0.0	..	..
Namibia	14.2	13.8	0.4	1.7	0.0	0.6	0.0	..	1.5
Nepal	10.0	3.0	7.0	3.4	0.0	0.0	10.3	0.2	0.0
Netherlands	26.3	11.7	14.6	6.0	0.1	0.0	0.0	0.2	20.3
New Zealand	22.5	9.4	13.1	5.0	0.3	0.1	0.0	0.2	17.4
Nicaragua	2.8	6.3	-3.5	3.9	0.0	0.1	0.0	0.9	-0.6
Niger	3.3	4.5	-1.2	1.9	0.1	0.0	0.0	0.4	0.2
Nigeria	21.9	2.4	19.5	0.8	30.7	0.0	0.0	1.5	-12.0
Norway	..	16.4	..	6.7	5.9	0.0	0.0	0.2	..
Oman	..	..	..	..	0.0	0.0	0.0	..	..
Pakistan	10.4	6.4	4.0	1.9	1.1	0.0	1.5	0.8	2.5
Panama	32.0	7.2	24.8	5.0	0.0	0.0	0.0	0.4	29.5
Papua New Guinea	33.2	11.0	22.2	5.8	6.7	8.2	0.0	0.3	12.8
Paraguay	20.3	7.8	12.5	1.5	0.0	0.0	0.0	0.2	13.8
Peru	20.8	4.3	16.6	3.1	0.6	0.8	0.0	0.3	18.0
Philippines	14.5	9.0	5.5	3.1	0.0	0.2	1.3	0.4	6.7
Poland	18.1	8.9	9.3	5.7	0.6	0.3	0.0	1.7	12.5
Portugal	..	4.5	..	5.0	0.0	0.1	0.0	0.3	..
Puerto Rico	..	6.6	..	..	0.0	0.0	0.0	..	..
Romania	14.5	7.6	6.9	3.5	3.3	0.1	0.0	2.1	4.9
Russian Federation	24.7	19.3	5.3	4.1	9.3	0.0	0.0	1.8	-1.6
Rwanda	-7.5	5.6	-13.1	3.2	0.0	0.1	0.0	0.2	-10.2
Saudi Arabia	34.6	10.0	24.6	5.8	43.6	0.0	0.0	1.0	-14.2
Senegal	13.2	5.3	7.9	4.1	0.0	0.4	0.0	0.4	11.1
Sierra Leone	-8.0	5.7	-13.8	2.5	0.0	3.6	0.0	0.2	-15.1
Singapore	51.2	13.2	38.1	2.2	0.0	0.0	0.0	0.5	39.8
Slovak Republic	28.4	15.4	12.9	5.0	0.0	0.0	0.0	1.3	16.6
Slovenia	23.1	16.9	6.2	7.1	0.0	0.0	0.0	0.4	12.9
South Africa	17.0	13.8	3.2	6.6	2.1	1.9	0.1	1.4	4.4
Spain	21.4	11.4	10.0	4.8	0.0	0.1	0.0	0.2	14.5
Sri Lanka	17.3	5.0	12.3	2.5	0.0	0.0	0.0	0.2	14.6
Sudan	..	5.5	..	2.6	0.0	0.0	0.0	0.2	..
Sweden	21.3	13.3	8.0	6.6	0.0	0.1	0.0	0.1	14.4
Switzerland	..	10.5	..	5.2	0.0	0.0	0.0	0.1	..
Syrian Arab Republic	19.0	3.5	15.5	2.8	22.5	0.1	0.0	1.6	-5.9

	Gross domestic savings	*Consumption of fixed capital*	*Net domestic savings*	*Education expenditure*	*Energy depletion*	*Mineral depletion*	*Net forest depletion*	*Carbon dioxide damage*	*Genuine domestic savings*
Tajikistan	..	5.3	..	..	0.0	0.0	0.0	..	..
Tanzania	3.4	2.8	0.6	2.9	0.0	0.0	0.0	0.2	3.2
Thailand	35.7	10.9	24.8	2.9	0.2	0.0	0.0	0.6	26.9
Togo	9.8	5.1	4.7	5.3	0.0	2.4	0.0	0.3	7.4
Trinidad and Tobago	29.1	11.2	17.9	4.1	10.8	0.0	0.0	1.8	9.4
Tunisia	24.2	8.7	15.4	6.0	2.4	0.7	0.4	0.5	17.3
Turkey	19.3	6.5	12.8	3.0	0.3	0.1	0.0	0.5	14.9
Turkmenistan	..	7.0	..	..	0.0	0.0	0.0	..	..
Uganda	7.5	5.0	2.5	2.6	0.0	0.0	3.4	0.1	1.6
Ukraine	16.3	18.4	-2.1	4.6	3.0	0.0	0.0	3.0	-3.4
United Arab Emirates	..	14.6	..	..	0.0	0.0	0.0	..	..
United Kingdom	15.1	10.4	4.8	4.5	0.8	0.0	0.0	0.3	8.2
United States	16.0	10.7	5.3	5.8	0.7	0.0	0.0	0.4	9.9
Uruguay	12.5	7.4	5.1	2.6	0.0	0.0	0.4	0.1	7.1
Uzbekistan	18.6	4.4	14.2	7.7	8.2	0.0	0.0	2.4	11.4
Venezuela	26.9	7.1	19.7	4.1	22.5	0.7	0.0	1.1	-0.4
Vietnam	21.1	5.0	16.2	1.4	4.0	0.1	3.4	0.8	9.2
West Bank and Gaza	..	..	..	..	0.0	0.0	0.0	..	..
Yemen, Rep.	12.8	7.7	5.1	3.9	34.7	0.0	0.0	..	-25.7
Zambia	9.8	9.9	-0.1	3.8	0.1	1.3	0.0	0.4	1.9
Zimbabwe	11.9	6.0	5.9	8.2	0.8	9.9	0.4	1.0	2.0

Notes

1. Human capital provides a type of endogenous technical progress. Cf. Weitzman and Löfgren (1997), who deal with exogenous technical change.

2. Carbon dioxide has an atmospheric residency time of 200 years, or a dissipation rate of roughly 1/2 percent per year. For an average growth rate in emissions of 5 percent per year, therefore, the equilibrium ratio of d to e is 1/11.

3. It must be recalled, however, that the total rent approach to measuring depletion tends to exaggerate the value of depletion, particularly for countries with very large resource endowments.

4. The question is also germane for unsustainable forest harvest programs.

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