Manual for Calculating Adjusted Net Savings

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September 2002

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Introduction

This manual is meant to provide a step-by-step description on how to update the adjusted net (genuine) savings calculations. Following an explanation of the motivation behind the adjusted net savings, the document proceeds through the calculation documenting all assumptions made, operations performed, and data sources.

Adjusted Net Savings

Adjusted Net Savings seeks to provide national-level decision makers with a clear, relatively simple indicator of how sustainable their country's investment policies are. While standard measures of "savings" and "investment" reflect changes in the value of a certain, limited set of assets, a more inclusive and realistic definition of what constitutes an asset can lead to a correspondingly more realistic picture of how a nation invests.

In standard national accounting, only the formation of fixed, produced capital is counted as an investment in the future and thus as an increase in the value of the assets available to society. Likewise, standard calculation of net saving rates include only depreciation in the value of human-made capital as a decrease in the value of a nation's assets. The adjusted net savings framework takes the broader view that natural and human capital are assets upon which the productivity and therefore the well-being of a nation rest. Since depletion of a non-renewable resource (or over-exploitation of a renewable one) decrease the value of that resource stock as an asset, such activity represents a *dis*investment in future productivity and well-being. In the same way, the creation of an educated populace and a skilled workforce—a nation's human capital—increase the value of that resource and might better be seen as an investment. In many cases, a nation which appears to be a net investor is, when natural and human capital are considered to be assets, actually decreasing the value of its collective assets with each year. Adjusted net savings, in such cases, become negative. Since all assets are finite in nature, this situation cannot persist; it is, in some sense, unsustainable.

Adjusted net savings represents a first-approximation numeric indicator of the degree to which a nation satisfies the Hartwick-Solow rule, often called "weak sustainability" (Barbier et al., 1994). "Weak" sustainability assumes that any type of capital is perfectly substitutable for natural capital as an input to production. From the adjusted net savings standpoint, for example, a nation which reinvested all of its profits from the exploitation of non-renewable natural resources in the formation of human capital through its educational system would have imposed no net opportunity cost on the country's future citizens. Whether or not this is precisely true is a hotly-debated issue, and this study makes no attempt to settle the issue. Rather, adjusted net savings seeks to offer policymakers who have committed their countries to a "sustainable" pathway a badly-needed, first-approximation indicator to track their progress in this endeavor.

Valuing depletion of subsoil resources is inherently difficult because it requires the estimation of changes in asset values, and these asset values in turn are dependent upon future values of prices, extraction costs and quantities extracted. Any set of assumptions about the future is likely to be debatable. The approach taken in the World Bank depletion estimates is chosen mostly for its parsimonious data requirements (reflecting the availability of internationally comparable data), rather than any inherent theoretical properties. Depletion is estimated as price minus average extraction cost times the quantity extracted. It can be shown that this is the theoretically correct measure if average extraction costs and marginal extraction costs are equal, and if the Hotelling rule is satisfied (so that prices rise at near-exponential rates). Since in the real world resource prices are flat-to-declining, the 'average rent' approach employed probably overstates the true value of depletion.

Detailed discussions of the economic theory underlying and motivating adjusted net savings as an indicator of sustainability can be found in Hamilton and Clemens (1999).

The Calculation

The following adjustments to the standard savings measure were made to arrive at adjusted net savings:

- *Gross national saving*. Calculated as the difference between GNI and public and private consumption.
- *Consumption of fixed capital was subtracted.* This represents the replacement value of capital used up in the process of production.
- *Current spending on education was added.* Standard savings measures only count as an investment that portion of total expenditure on education (usually less than ten percent) which goes toward fixed capital such as school buildings; the rest is considered consumption. Although it is not obvious exactly how to measure changes in the value of a nation’s human capital stock (Jorgensen and Fraumeni, 1992), it is clear that within a adjusted net savings framework that considers human capital to be a valuable asset, expenditures on its formation cannot be labeled as simple consumption. As a lower-bound first approximation, the calculation thus included current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment. The case for its inclusion is further discussed in World Bank (1996).
- *Rent from the depletion of natural resources was subtracted*. Rent was measured as the market value of extracted material minus the average extraction cost. As discussed above, this is an approximation of the Net Price valuation method (which uses marginal extraction cost) which in turn is an approximation of the more exact User Cost method. Energy, mineral and forest depletion were included. All resources considered were non-renewable, with the exception of forest resources; in the case of forestry, rent on depletion was calculated as the rent on that amount of extraction which exceeded the natural increment in wood volume.
- *Damages from Carbon Dioxide emissions were subtracted*. This calculation effectively expands the notion of a national “asset” yet further to include its unpolluted air. Ideally, the number subtracted would reflect marginal damages from the entire range of air pollutants emitted; as a first approximation, a conservative estimate for damages from a single major pollutant was used.

In short, the adjusted net savings rate was calculated as:

$$\mathrm{NAS} = (GNS - D_h + CSE - \Sigma R_{n,i} - CD) / GNI$$

where NAS = Adjusted Net Savings Rate
GNS = Gross National Saving
D_h = Depreciation of produced capital
CSE = Current (non-fixed-capital) expenditure on education
$R_{n,i}$ = Rent from depletion of natural capital$_i$
CD = Damages from carbon dioxide emissions
GNI = Gross National Income at Market Prices

An annual average NAS was calculated from 1970 for all countries for which the above data were available. The calculation of each element will be discussed in turn.

Gross National Saving.

Gross national saving in current US$ can be obtained from the World Development Indicators (WDI), World Bank.

Consumption of Fixed Capital.

The decrease in the value of produced assets was subtracted. Data on consumption of fixed capital was taken from the United Nations Statistics Division's *National Accounts Statistics: Main Aggregates and Detailed Tables, 1997*, extrapolated to 1999. Where country data was unavailable it was estimated as follows. Available data on depreciation as a percent of GDP was regressed against the log of GDP per capita. This regression was then used to estimate missing depreciation data. Regression: Dep/GDP = a + (b * Ln(GDP/cap)). The regression was estimated on a five yearly basis. i.e. regression in 1970 was used to estimate depreciation as a percent GDP in years 1970-1974. This was then used to calculate depreciation as a percent of GNI. Where data was missing for only a couple of years in a country, the same rate of depreciation as a percent of GNI was applied.

Human Capital Investment.

The process of calculating adjusted net savings is, in essence, one of broadening the traditional definition of what constitutes an asset. Up until this point, standard measures of net savings (gross savings minus depreciation of produced capital) were adjusted downward by an estimate of depreciation in the value of natural capital due to natural resource depletion and an allowance for pollution damages. The crucial message is that if a natural resource like oil is regarded as an asset which contributes to production as much as the machine which burns it, then liquidation of a natural capital stock must be regarded as a *dis*investment rather than an investment. There exist additional stocks, however, whose contribution to production is difficult to deny yet which are not considered assets even within the extended definition of savings used so far. Perhaps the most important of these is the knowledge, experience and skills embodied in a nation's populace, its so-called *human capital*.

The world's nations augment the stock of human capital in large part through their educational systems, into which they collectively pour trillions of dollars each year. Standard national accounts label as an *investment* less than ten percent of this amount, that portion which is spent on fixed capital such as school buildings. Non-fixed-capital expenditures on education (called "current expenditures") include teachers' salaries and the purchase of books, and are treated strictly as consumption—a disinvestment in the future. Within the adjusted net savings framework, however, this is clearly incorrect. If a country's human capital is to be regarded as a valuable asset, expenditures on its formation must be seen as an investment (Hamilton 1994).

Controversy exists surrounding the correct method of valuing such an investment in the human capital stock, since one dollar's current expenditure on education does not necessarily yield exactly one dollar's worth of human capital (see, for example, Jorgensen and Fraumeni, 1992). Traditional saving rates should theoretically be adjusted by the change in value of human capital to reflect this investment, but there is not as yet consensus on how to carry out this valuation. At the very least, it is undoubtedly true that current educational expenditure does not represent consumption from the standpoint of adjusted net savings. As a first approximation, therefore, rates of adjusted net savings can be adjusted upwards according to rates of current spending on education.

Data on current education expenditures came from UNESCO in local currency units. Much of the data is spotty with the most recent data referring to several years ago. Given that education expenditures as a percent of GNP rarely undergo sudden changes these missing data points were estimated. This was done by taking GNP in local currency unit to calculate the percentage spent on education. This was then adjusted by the GNP/GNI ratio to calculate current education expenditures as a percent of GNI.

Rent from Energy Depletion

Energy depletion covers crude oil, natural gas, and coal (hard and lignite). As in the case of all other nonrenewable resources, rent was estimated as:

Rent = (*Production Volume*) (*International Market Price - Average Unit Production Cost*)

Natural Gas

Production

None of the available data sources provided a complete set of data (i.e. covering all countries and years). Therefore, data was obtained from different sources, with priority given to the most complete and reliable sources.

Source:	
British Petroleum (BP)	Statistical Review of World Energy www.bp.com/downloads
International Energy Agency (IEA)	www.iea.org http://www.iea.org/statist/key2001/keyworld-2001.pdf
International Petroleum Encyclopedia (IPE)	International Petroleum Encyclopedia, 2001
United Nations (UN)	Monthly Bulletin of Statistics

The sources were used in the following order: 1. BESD, 2. BP, 3. IEA, 4. IPE, 5. UN. The BESD database is the old World Bank database, now replaced by SIMA.

Price

Natural gas has no single *de facto* price and as a result its world price is estimated. Data on natural gas export prices was found to follow a similar pattern. As a result, the world price for gas was estimated as the weighted average of all available prices in this set in any given year. Prices were obtained from three sources: 1) Global Commodity Markets: A Comprehensive review and Price Forecasts, World Bank, 2) BP online database http://www.bp.com/downloads in the publication entitled *Statistical Review of World Energy*, 3) Natural Gas Division, Energy Sector, Dept. of Natural Resources Canada (http://www.nrcan.gc.ca/es/erb/ngd/reports/2000_evaluation.pdf), 'Canadian Natural Gas: Review and Outlook'. Data was obtained from the executive summary.

Missing data from 1970-1972 were obtained from estimating a linear relationship between estimated average world prices and US internal gas prices over the period 1973-2000. The two were found to be highly linearly dependent with a correlation coefficient of 0.9. The estimate for export price in 1973 was also calculated in this way as the weighted average of available prices was found to be an outlier.

Cost

For most countries, only data for a single year or patchy data was available. One of two methods was used to obtain year-by-year estimates of production costs: 1) If data for a single year were available, it was assumed that production costs remained constant in real terms. Production costs for each year in current dollars were obtained from the single data point and a time series of the GDP deflator. The US GDP Deflator is downloaded from http://www.access.gpo.gov/usbudget/fy2002/hist.html. 2) if data for two different years were available with an interval of no data, estimates for the intervening years were calculated as a linear interpolation between the two points. Those countries for which no production cost data were available were assigned a surrogate production cost from another country. The choice of surrogate country was made on the basis of 1) geographic proximity and 2) similarity between the ratios of offshore active drilling rigs to total active drilling rigs between the two countries. The numbers of active offshore and total drilling rigs were obtained from Meyer *et al*. (1994), and selected statistics on onshore vs. offshore production came from Whitehead (1983).

Unit Rent

Unit rent was calculated by subtracting unit cost from price. For some countries this difference was negative. It was assumed that this anomaly was due to incomplete cost data (from the assumption of constant real costs). The cost data in these particular cases was discarded and re-estimated from rental rates. Rental rates were calculated as:

$$\text{Rental rate} = \frac{price - unit\ \cos t}{price}$$

Positive rental rates were then derived by calculating an average of the positive rental rates of the most recent five years in each country. These positive estimates were then multiplied by price to derive positive unit rents.

Hard Coal

In the case of coal the calculation of rents is complicated by the fact that: (i) coal has different types; steam and coking coal; (ii) each of these types has a different heat value, which differs from country to country; and (iii) both types have different export prices that differ from country to country.

Production

As mentioned above, hard coal production was measured as an aggregate of steam and coking coal. Available literature reports production volume as an aggregate of steam and coking coal. Since steam coal makes more than three quarters of global hard coal production (IEA, 1995e), it was assumed that the data represented an aggregate of both types standardized to an average 'coal equivalent' of steam coal with a heat value of 0.6995 toe/ton. It was further assumed that all data collected on production volume uniformly represented this type of coal.

Data was obtained from several sources as none provided continuous data for all countries. The UN Monthly Bulletin of Statistics was the preferred data source. Up to date IEA data was obtained from Coal Information, 2001. Missing data was extrapolated using the time trend over the past three years. In cases where this measure produced negative estimates, two, rather than three, most recent years were used or the most recent year's figure was assumed

Price

Price estimation was complicated by the fact that both steam and coking coal do not have a single export price. Prices and heat values of each differ from country to country. The price was calculated as follows.

Export price data was collected for steam and coking coal for several countries. A world average export price for both coking coal and steaming coal was calculated as the average of available prices for that year, weighted by national average heat value. Where calorific value information did not exist, OECD countries' average calorific value was used. This was because available data (from IEA Statistics) reported calorific values for OECD countries only. This method produced a price series from 1970-2000 for coking coal and 1980-2000 for steaming coal. The missing data for steaming coal was estimated from coking coal data, using the average price relationship between the two types of coal. This was done by first adjusting steaming coal price data from 1980-2000 to coking coal calorific value i.e. by multiplying steam coal prices by Cc(price)/Csteam – see Table 1. The average relationship between coking and steam coal prices over the period was found to be 0.88. This was used to estimate the steam coal prices from 1970-1979.

Table 1 – Calorific values		
Csteam	0.594 toe/ton	calorific value of steam coal
Cc(price)	0.687 toe/ton	average calorific value for coking coal for those countries from which price data is used
Cc(prod)	0.699 toe/ton	calorific value for hard coal in which production volumes are reported
Csoft	0.269 toe/ton	calorific value for soft coal

The estimated export prices of steam and coking coal, adjusted to reflect the same net calorific value, were used to calculate an average world price for hard coal. As steaming coal reflected 75% of production and coking coal 25%, the price series were weighted respectively. The world average hard coal export price in each year from 1970-2000 was approximated as the average of the export prices for steam and coking coal, with steam coal given a weight of three quarters and coking coal a weight of one quarter to reflect the aforementioned relative production of the two types on a global level. Note that in averaging steam coal and coking coal prices, the steam coal prices were adjusted to be commensurable in terms of heat value with the coking coal prices, meaning that the final hard coal price series is in terms of a mixed steam/coking coal with a standard heat content equal to the average heat content of coking coal in the nine countries included in the coking coal average price. In order to make this final price commensurable with the standardized heat value in which hard coal production volumes were reported (Ccprod), it was scaled up slightly by a factor of Cc(prod)/Cc(price). The result is a world price for hard coal at 0.699 calorific value.

Data on prices was obtained from IEA Statistics: Coal Information, 2001. Data on calorific values was obtained from IEA (1995d).

Costs

Since production costs were also separately reported for steam coal and coking coal, a similar method of estimating a single, aggregated hard coal production cost was required. Production costs for steam coal came from: Australia, USA, Canada, Colombia, South Africa, Indonesia (IEA, 1994b); Poland (IEA, 1995d); Czech Republic (IEA, 1994a); China (Doyle, 1987) [converted to US$ with IMF (1996)]; Russia (Tretyakova and Heinemeier, 1986) [converted to US$ with The Economist Intelligence Unit (1991; 1992)]; Mexico (World Bank, 1989); and India (Bhattacharya, 1995). Production costs for coking coal came from: Australia, USA, Canada, South Africa (IEA 1994b); Poland (IEA, 1995c and 1994b); and India (Bhattacharya, 1995). Since coking coal data were scarce, only the steam coal data were utilized and an aggregate hard coal production cost was constructed by assuming production cost varies with the heat content and quality of coal just as the market price does. That is, it was assumed that after adjusting for heat value, the ratio of steam coal production cost to coking coal production cost is 0.77. Since the production cost figures came with no information on heat content, it was assumed that the heat content of steam coal for this calculation was the average heat content of the steam coal exports analyzed in the price calculation (Cc(price)). To get an approximate aggregate steam-and-coking coal production cost for each country, the steam coal production cost was first scaled up to be commensurable in heat content with the production volumes (i.e. multiplied by Cc(prod)/Csteam) and a weighted average was found between the heat-adjusted steam coal figure and an estimated coking coal production cost, the latter being obtained by dividing the former by 0.77. The weights in this weighted average, as above, were three-quarters for steam coal and one-quarter for coking coal. In shorthand form, the estimated aggregate hard coal production cost for each country was derived from the steam coal production cost by multiplying by the following factor: (Cc(prod)/Csteam)(1+((1/4)((1/0.77)-1))). As in the case of oil, this gave production costs for a single year only, in almost all cases. A time series of production costs from 1970-1994 was generated by assuming constant real production costs and adjusting the single-year figure by a GDP deflator. The assumption of constant real production costs is a strong but necessary one, and as in the case of metals & minerals described earlier, it resulted in a few falsely negative unit rents for certain country-years—mostly on the periods 1970-71 and 1993-1994. Each negative unit rent was replaced by an estimated unit rent calculated by multiplying the average rental rate for all years in which calculated unit rent was positive by the market price in the year of the unit rent being replaced. As in the case of metals and minerals, countries for which no production cost data were available were assigned a “surrogate” country’s production cost based on geographic proximity; when no such country was available, a world average production cost was used.

Unit Rent

See natural gas unit rent

Lignite/Soft Coal/Brown Coal

Soft/brown coal comprises coal that is non-agglomerating with a gross calorific values less than 5 700 kcal/kg (23.9 GJ/t) containing more than 31 % volatile matter on a dry mineral matter basis. There are two categories of soft coal, namely: sub-bituminous coal and lignite. The former is included in steam coal for many countries and as such, is counted as hard coal. Therefore, lignite has been used to represent soft coal in the calculations.

As in the case of hard coal, to calculate soft coal rent measures of production volume, coal price and production costs had to be ascertained, and heat value and quality adjustments made. Calculations were complicated since no export prices are not available (it is only traded internationally in minute quantities) and domestic prices are often distorted by subsidies. As with hard coal, production cost data is also scarce. As a result, price and cost measures were imputed from hard coal figures.

Production

Production volume was measured as the total quantity of lignite, in metric tons. Data is obtained from the UN Monthly Bulletin of Statistics and the IEA Coal Information, 2001. Unavailable data was filled using a time trend over the past three years.

Price

Existing literature does not report export prices for soft coal, primarily because it is not traded internationally. Local prices for the resource could not be used because of price distortions which exist in most producing countries. Soft coal price was therefore estimated from hard coal export prices, based on the assumption that the difference between prices of the two types of coal results from heat content and quality differences. Therefore, before estimating soft coal price, hard coal prices were adjusted for soft coal heat content and quality differences.

Heat content difference was adjusted by multiplying all the prices by the factor Csoft/Cc(prod) – see Table 1. For quality differential, the ratio of soft- to hard-coal price was calculated for Czech Republic as it had data for both grades. The ratio was calculated as 0.6875. Soft coal average price was then estimated as:

Soft coal average price = hard coal average price * (Csoft /Cc(prod))*0.6875

Cost

Data on soft coal production cost was not available in the literature. The steam coal production cost figures used to estimate hard coal production costs were also used in this case, with some adjustments to the data for heat content and quality differences.

Compared to hard coal, soft coal has a relatively lower heat content and its quality is lower, e.g, soft coal has higher content of ash and sulfur.

The first adjustment to the steam production cost data was to convert them to soft coal calorific value by multiplying with the factor Csoft/Csteam.
Secondly, the data were adjusted to the quality of soft coal. To do this, the ratio of production cost of soft coal to hard coal was calculated from Czech Republic data and the result was 0.6. This was assumed to reflect quality difference between the two types of coal. An estimate of soft coal production cost was then calculated as:

Soft coal unit production cost =
*Steam coal unit production cost * (Csoft /Csteam) * 0.6875*

Since there was only one data point for all the countries, except Russia which had data for 1980, 1985 and 1990, the estimates from the function above were assumed to be constant real production costs for the countries in question. The data was then adjusted by US GDP deflators to calculate costs in current US dollars for all other years. For Russia, data for the years between 1980 and 1985, and 1985 and 1990 was interpolated. For 1970 - 1979 and 1991 - 1998, the 1980 and 1990 prices, respectively, were deflated to derive production costs in current US dollars. 'Surrogate' costs for countries with no cost data were also used in this case, using the same procedure followed in hard coal for assigning counties with no data to surrogate countries.

Unit Rent

See natural gas unit rent.

Oil

Production

As in the case of gas, none of the available data sources provided a complete set of data. Therefore, data was obtained from different sources, ,with priority given to the most complete and reliable sources.

Source:	
British Petroleum (BP)	Statistical Review of World Energy www.bp.com/downloads
International Energy Agency (IEA)	www.iea.org http://www.iea.org/statist/key2001/keyworld-2001.pdf
International Petroleum Encyclopedia (IPE)	International Petroleum Encyclopedia, 2001
United Nations (UN)	Monthly Bulletin of Statistics

The sources were used in the following order: 1. SIMA, 2. BP, 3. IEA, 4. IPE, 5. UN. SIMA is the World Bank’s statistical database.

Price

Price is calculated from the average of four spot crude oil prices in dollars per barrel. This is converted to dollars per ton using a conversion factor of 7.3. Data is available for downloading at www.bp.com/download in the Statistical Review of World Energy.

Cost

Data for costs was mostly for one year (1993 for most countries). In these cases costs were assumed constant in real terms and were deflated by US GDP deflators to derive costs of earlier years and inflated to derive costs for later years. The US GDP Deflator is downloaded from http://www.access.gpo.gov/usbudget/fy2002/hist.html. Average production cost data came from: Ukraine (IEA, 1996); Russia (IEA, 1994c; IEA 1995g; IEA 1995c; Sagers, 1995); Venezuela and Mexico (IEA 1995c; IADB 1981); Libya, Malaysia, Nigeria, USA, Gabon, Egypt, North Sea/Great Britain (IEA, 1995c); Norway (Adelman, 1987); Ecuador, Peru, Trinidad & Tobago, Argentina, Bolivia, Brazil, Chile and Colombia (IADB, 1981); Iran, Iraq, Saudi Arabia, Kuwait, United Arab Emirates, Oman (IEA, 1995c; Jenkins, 1989); Indonesia (IEA, 1995c; Repetto et al., 1989); Canada (IEA, 1995c; Smith, 1992); and Europe (EIA, 1995). Some countries like Indonesia, Canada and Ukraine had data for more than one year. Indonesia had data for 1970 - 1974 and for 1993. Cost figures for years between 1974 and 1993 were calculated as a linear interpolation of 1974 and 93 data. For other years, 1993 figure was assumed constant in real terms and was inflated by US GDP deflators to derive costs in current US dollars. For countries that had discontinuous time series, e.g., Russia, US and Abu Dhabi, a weighted average of available data was taken and assumed constant in real terms for the country in question for the most recent year for which data is available. The cost was then applied to other years by adjusting with US GDP deflators. The countries which did not have cost data were assigned surrogate costs from other countries. The choice of surrogate countries was made on the basis of geographic proximity between the countries and similarity between the ratios of offshore active drilling rigs to total active drilling rigs between the two countries. The numbers of active offshore and total drilling rigs were obtained from Meyer et al. (1994), and selected statistics on onshore vs. offshore production came from Whitehead (1983).

Unit rent

See natural gas unit rent.

Rent from Metals and Minerals

Metals and minerals included in the calculation are: bauxite, copper, gold, iron, lead, nickel, phosphate, silver, tin, zinc.

Production Data

Production volume was measured as total metric tons of each metal/mineral in each country. Data was obtained from the USGS Minerals Yearbook which is available online at http://minerals.usgs.gov/minerals/pubs/commodity/myb/. Unfortunately, each minerals data is released at different times. In some cases gaps are filled using linear extrapolation of approximately the past four years of data.

Price

Source: UNCTAD Monthly Commodity Price Bulletin.

Costs

Production costs for metals and minerals are proprietary information and very difficult to obtain. Therefore, they are updated annually using the GDP deflator on data existing in the spreadsheet. In addition to bibliographical sources, the project received expert assistance from Donald Bleiwas and Lorie Wagner of the US Geological Survey. Sources for metal production costs, together with the date of data presented therein, were: **Bauxite** 1984-1992 (World Bank, 1994), 1989 (Bleiwas, 1996) and 1985 (Bureau of Mines 1987); **Copper** 1975-1992 (World Bank, 1994), 1989 (World Bank, 1989), 1988 (Bleiwas, 1996), and 1985 (Bureau of Mines, 1987); **Gold** 1992 (World Bank, 1994), 1991-1992 (Bleiwas, 1996), and 1985 (Bureau of Mines, 1987); **Iron Ore** 1985 (Bureau of Mines, 1987); **Lead** 1988-1991 (World Bank, 1994), 1990 (Bleiwas, 1996), and 1985 (Bureau of Mines, 1987); **Nickel** 1990-1992 (World Bank, 1994) and 1981 (Bleiwas, 1996); **Phosphate Rock** 1985 (Bureau of Mines, 1987); **Silver** 1985 (Bureau of Mines, 1987); **Tin** 1989 (World Bank, 1991) and 1985 (Bureau of Mines, 1987); and **Zinc** 1988-1991 (World Bank, 1994), 1990 (Bleiwas, 1996), and 1985 (Bureau of Mines, 1987). In all cases, the most recent cost estimate for each country was used. A time series of costs was constructed from each single-year figure, as for oil, by assuming constant real costs and adjusting with a GDP deflator. Cost data in most cases were the sum of mining costs, milling costs, smelting/refining/transportation costs, capital recovery (depreciation), and 15% Discounted Cash Flow Rate of Return, minus byproduct credit. In cases where data were presented in less detail (e.g. presented simply as a single, aggregate figure for "production cost"), that number, for lack of any other, was used.

Unit Rent

See natural gas unit rent.

Rent from Net Forest Depletion

The renewable character of forest resources makes them fundamentally different from all other resources treated so far. Since wood stocks can be renewed, extraction of wood is not necessarily a disinvestment in the future and need not be counted against adjusted net savings. What *is* a disinvestment is *unsustainable* extraction of wood stocks, i.e. a disinvestment in the future productivity of forests by extracting more wood than the forest is able to renew. The correction to saving rates was thus not simply rent on wood extraction, but rather rent on that portion of wood extraction which exceeded natural increment in the country for a particular year. Net natural growth is not added to savings when it is positive, although this will bias the estimates against sustainability. Vitousek et al (1986) estimate that less than 33 percent of standing forests are merchantable. A clear dichotomy is at work: all of the timber in net depletion countries is merchantable, by definition, while probably less than one-third is merchantable in net growth countries. It is likely that mechanically adding net forest growth to savings would implicitly include the growth of many uneconomic trees (Hamilton and Clemens, 1999).

Rent = (Roundwood Production – Increment) * Avg Price * Rental Rate

Data is mainly downloaded from the FAOSTAT Forestry Database.

Roundwood Production

Source: FAOSTAT. Roundwood Production [CUM] Code: 1861

Increment

Increment = Increment per hectare on productive forest land * forest area.

First, estimates of mean annual increment per hectare in commercial-quality wood mass (m^3/hectare/year), were calculated by creating a table of "potential productivities" based on a map of the same created from soil, temperature and rainfall data (Mather, 1990). In many cases we have relied on expert opinion to review these numbers. Estimates of the mean annual increment for most temperate countries came from FAO/UNECE (1992), and for a small number of tropical countries from Kanowski et al. (1992), Lamprecht (1989), and Duvigneaud (1971). Forest areas for 1970, 1980, and 1990 were obtained from previous work done in the World Bank. This work obtained the area figures for most tropical countries from the United Nations Food & Agriculture Organization, for most temperate countries from FAO (1994), and for Former Soviet Union countries from the International Institute for Applied Systems Analysis in Vienna. Some additional data were collected from WRI (1995). All area figures were multiplied by a factor of 0.8 to allow for the fact that roughly a fifth of any given country's forest area is not accessible for extraction (due to steep slopes, rivers, etc.). In most cases, forest areas in 1971-1979 and 1981-1989 were estimated by linear interpolation between the above figures and areas in 1991-1994 by extrapolation of the 1980-1990 trend. Where data for 1970 were unavailable, data on the period 1970-1979 were estimated by back-extrapolating the 1980-1990 trend. Thus, the product of the mean annual increment per hectare in

commercial quality wood, the factor of 0.8, and the forest area was determined for each country in each year from 1970-1994. This number will be called the *increment* for that country-year.
Some of the resulting increments were further adjustment. In certain countries, particularly in East Africa, a large portion of roundwood production comes from land which does not have sufficient tree density to be classified as a forest by FAO. Table 6-5 in Millington et al. (1994) indicates that approximately 67% of roundwood production in East Africa comes from "forest" land, as opposed to 94% in Central Africa (Table 6-4 in Millington et al., 1994). Increment figures for certain countries were multiplied by a factor of 1/0.67 to reflect non-forestland increment. These countries were Rwanda, Burundi, Uganda, Kenya, Tanzania, Malawi, Haiti, Egypt, and Bangladesh.

Forest Area

Forest Areas for 1970, 1980, 1990, and 2000 were obtained from the FAO and WRI. Current updates can be obtained from FAO's '*State of the Worlds Forest, 2001'*. In all countries area figures were adjusted for forests that are inaccessible for extraction due to steep slopes, rivers, etc. On the advice of expert opinion, it was assumed that only 80% of forests are productive in all countries except Denmark and Solomon Island. In Denmark and Solomon Islands, 100 % and 10% of the forests, respectively, are productive. Since available data provided only four data points, namely 1970, 1980, 1990, and 2000 the rest of the data had to be estimated. To estimate data for interval years, i.e., 1971-1979 1981-linear interpolation was used. Area estimates for the years 2001- should be extrapolated from the 1990-2000 trend. Where data for 1970 were unavailable, data on the period 1970-1979 were estimated by back- casting based on the 1980-1990 trend.

Rental Rate

Rather than collect information on production costs, for the purposes of this study a set of *rental rate* estimates was collected from a group of experts and some previous research. Rental rate is defined as ((Market Price - Production Cost)/(Market Price)).

A survey of the literature found rental rates to approximate 50%. Estimated rental rates of roughly 50% were estimated for Indonesia (Carbonnier, 1996). Repetto *et al*. (1989) used a figure of 55% for Indonesia. A study on the Philippines by D. Angeles *et al*. (1988) found figures of 42% and 58% on two different sites (average 50%). A rental rate of 48% for Thailand was calculated by a World Bank expert. Based on these figures, an approximate rental rate of 50% was used for East Asia, Southeast Asia, and South Asia.

World Bank staff provided data on Cameroon which was used to estimate a rental rate of 30%. A study by Gillis (1988) found the rate in Ghana to be 26%. Based on these figures, a lower rate of 30% was used for all of Africa.

A study by Cottle *et al*. (1990) demonstrated a rental rate of approximately 55% for a Brazilian forestry operation. Solórzano *et al*. (1991) provide data on Costa Rican internal prices which show an average rental rate in recent years of 68% when sawmill costs are excluded (probably too high, but effects on the price of processing are difficult to separate since data on unprocessed logs are not presented). World Bank staff provided data that showed an approximate rate of 52% in Ecuador. Based on these results and expert opinion, a rental rate of 55% was assumed for all of Latin America.

Finally, World Bank staff estimated a rental rate of 40% for temperate country forestry operations.

Average Price

The price of roundwood, in each country, was calculated as a weighted average of fuelwood price and industrial wood price. Fuelwood price data was taken from FAO (1995) and roundwood prices from the FAOSTAT database available online. The price was calculated as:

$$\text{Avg Price} = (Q_f * P_f) + (1 - Q_f * P_e)$$

where:

P_f = Price of fuelwood
P_e = Regional export price of industrial roundwood (which does not reflect fuelwood)
Q_f = Fuelwood quotient, i.e. percentage of total roundwood production that is fuelwood

Industrial Roundwood Price

Price for industrial roundwood was derived from export quantity and value of traded roundwood in each country, obtained from FAOSTAT data base (series Industrial Roundwood, Export quantity and value. Code 1865.) This data was used to derive regional prices, which were applied to corresponding countries. Individual country price data was not used because it was considered to be noisy.

Fuelwood Price

Fuelwood price data is available for 21 developing countries from 1970-1992 from the FAO publication, Forest Products Prices. This was an annual publication, but stopped in 1995. The latest data is for 1992. Given the patchiness of the data, an average of the prices is taken. Using the MUV inflation index, prices are converted to real prices and forecasted for missing years. The MUV index is a unit value index (in U.S. dollars) of manufactures exported from the G-5 countries (France, Germany, Japan, the United Kingdom, and the United States) weighted proportionally to the countries' exports to the developing countries.

Fuelwood Quotient

Calculated as the percentage of total roundwood production that is fuelwood. Data was taken from the FAOSTAT database. Series: Woodfuel Production. Code 1864. Roundwood Production. Code 1861.

Damages from Carbon Dioxide Emissions.

Carbon dioxide emissions data is published in the World Bank's World Development Indicators and the source is the Carbon Dioxide Analysis Centre. However, data is not available for the last 3 years. We estimate the most recent years by taking the average ratio of CO_2 emissions to GDP (in constant local currency unit) over three years, and applying this ratio to GDP (in constant local currency unit) for the missing years.

The global marginal social cost of a metric ton of carbon emitted is assumed to be $20 in 1995 (Fankhauser, 1994). This is deflated for other years using the U.S.A. GDP deflator. As the emissions data is for CO_2 and the damage estimate per ton is for carbon, the emissions data is transformed by 12/44.

References

Adelman, M. A. 1987. "Offshore Norwegian Development Cost Calculated From Project Data," *Energy Exploration & Exploitation*, Vol. 7, No. 1, pp 51-62.

Barbier, Edward, Joanne C. Burgess and Carl Folke. 1994. *Paradise Lost? : the ecological economics of biodiversity*. London: Earthscan.

Bartelmus, Peter, Ernst Lutz and Stefan Schweinfest. 1993. "Integrated Environmental and Economic Accounting: A Case Study for Papua New Guinea." In Lutz, Ernst, ed., *Toward Improved Accounting for the Environment*, pp 108-143. Washington, DC: World Bank.

Bhattacharya, Subhes C. 1995. "Estimation of subsidies on coal in India." *Natural Resources Forum.* Vol. 19. No. 2. pp. 135-142.

Bleiwas, Donald. 1996. Denver Office of the US Geological Survey. Personal Communication.

British Petroleum. 2001. *Statistical Review of World Energy*. London.

Bureau of Mines. 1987. *An Appraisal of Minerals Availability for 34 Commodities*. United States Dept. of the Interior. Washington, DC: US Government Printing Office.

Carbonnier, Louis. 1996. AGRAF division, World Bank. Personal communication.

Cottle, Laura E., Gerard F. Schreuder and Antonio A. A. de Barros. 1990. *Brazil: A Country Profile of the Forests and Forest Industries.* Working Paper 27. Seattle: Center for International Trade in Forest Products, University of Washington.

delos Angeles, Marian S., et al. 1988. "The Private Costs of Commercial Forestry, Reforestation and Social Forestry." *Journal of Philippine Development*. Vol. 15. No. 1. pp. 113-135.

Doyle, Guy. 1987. *China's potential in international coal trade.* London: International Energy Agency Coal Research.

Duvigneaud, P., ed. 1971. *Productivity of Forest Ecosystems*. Paris: UNESCO.

EIA (Energy Information Administration). 1995. *Performance Profiles of Major Energy Producers 1993*. Washington, DC: US Dept. of Energy.

El Serafy, Salah. 1989. "The Proper Calculation of Income from Depletable Natural Resources." pp 10-18. In Ahmad, Yusuf, Salah El Serafy and Ernst Lutz, eds., *Environmental Accounting for Sustainable Development*. Washington, DC: World Bank.

Fankhauser, Samuel. 1994. "The economic costs of global warming damage: A survey." *Global Environmental Change*. Vol. 4. No. 4. pp. 301-309.

FAO (Food and Agricultural Organisation). 1994. *Forest Products Yearbook 1993*. Rome.

FAO (Food and Agricultural Organisation). 2001. *State of the World's Forests, 2001*. Rome.

FAO/UNECE. 1992. *The Forest Resources of the Temperate Zones.* Vol. 1: General Forest Information. New York, United Nations.

Gillis, Malcolm. 1988. "West Africa: resource management policies and the tropical rain forest." In Repetto, R. and M. Gillis, eds. *Public Policies and the misuse of forest resources*. London: Cambridge Univ. Press.

Hamilton, Kirk and Michael Clemens. 1999. "Genuine Savings Rates in Developing Countries" *The World Bank Economic Review* Vol. 13 No. 2, pp 333-56.

Hamilton, Kirk. 1995. "Sustainable development, the Hartwick rule and optimal growth." *Environmental and Resource Economics*, Vol. 5, No. 4, pp 393-411.

Hamilton, Kirk. 1994. "Green Adjustments to GDP." *Resources Policy* Vol. 20 No. 3, pp 155-168.

IADB (Inter-American Development Bank). 1981. *Investment and Financing Requirements for Energy and Minerals in Latin America,* Washington: IADB.

IMF (International Monetary Fund). 1996. *International Financial Statistics Yearbook 1995*. Washington, DC.

International Energy Agency. 1993*.* *Coal Information 1993*. Paris: OECD.

International Energy Agency. 1994a*.* *Coal Information 1994*. Paris: OECD.

International Energy Agency 1994b. *Energy Policies of the Czech Republic*. Paris: OECD.

International Energy Agency. 1994c. *Russian Energy Prices, Taxes, and Costs 1993.* Paris: OECD.

International Energy Agency. 1995a*.* *Coal Information 1995*. Paris: OECD.

International Energy Agency. 1995b. *Energy Statistics and Balances of Non-OECD Countries 1992-1993*. Paris: OECD.

International Energy Agency. 1995c. *Middle East Oil and Gas*. Paris: OECD.

International Energy Agency. 1995d*.* *Energy Balances of OECD Countries 1992-1993*. Paris: OECD.

International Energy Agency. 1995e. *Energy Policies of Poland*. Paris: OECD.

International Energy Agency. 1995f. *Oil, Gas & Coal: Supply Outlook.* Paris: OECD.

International Energy Agency. 1995g. *Energy Policies of the Russian Federation, 1995 Survey*. Paris: OECD.

International Energy Agency 1996. *Energy Policies of Ukraine, 1996 Survey*. Paris: OECD.

International Energy Agency. 2001. *Coal Information 2001*. Paris: OECD.

Jenkins, Gilbert. 1989. *Oil Economists' Handbook*, 5th ed. Vol. 2. New York: Elsevier.

Jorgensen, D. W. and B. M. Fraumeni. 1992. "The Output of the Education Sector." In Zvi Griliches, ed., *Output Measurement in the Service Sectors*. Chicago: University of Chicago Press.

Kanowski, P. J. et al. 1992. "Plantation Forestry." In Sharma, Narendra P., ed. *Managing the World's Forests: Looking for Balance between Conservation and Development.* Dubuque, Iowa: Kendall/Hunt Publishing Co.

Lamprecht, Hans. 1989. *Silviculture in the Tropics*. Eschborn, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit.

Mather, A. 1990. *Global Forest Resources*. London: Belhaven Press.

Meyer, Sandra *et al*. 1994. *Natural Gas Statistics Sourcebook.* Oil & Gas Journal Energy Database Publications. Tulsa, Oklahoma: PennWell Publishing Co.

Natural Resources Canada. 2001. Canadian Natural Gas: Review and Outlook. http://www.nrcan.gc.ca/es/erb/ngd/reports/2000_evaluation.pdf

Repetto, Robert et al. 1989. *Wasting Assets: Natural Resources in the National Income Accounts*. Washington, DC: World Resources Institute.

Sagers, Matthew et al. 1995. "Resource Rent from the Oil and Gas Sector and the Russian Economy," *Post-Soviet Geography*, Vol. 36, No. 7, pp 389-425.

Smith, Roger. 1992. "Income Growth, Government Spending, and Wasting Assets—Alberta's Oil and Gas." *Canadian Public Policy*. Vol. 18, No. 4, pp 387-412.

Solórzano, Raúl et al. 1991. *Accounts Overdue: Natural Resource Depreciation in Costa Rica*. Washington, DC: World Resources Institute.

Tretyakova, Albina and Meredith Heinemeier. 1986. *Cost Estimates for the Soviet Coal Industry: 1970 to 1990.* Washington, DC: Center for International Research, Bureau of the Census, US Dept. of Commerce.

United Nations. 1997. National Accounts Statistics: Main Aggregates and Detailed Tables, 1996-97. New York, NY.

United Nations. 2001. Monthly Bulletin of Statistics. Vol. LV No. 7 July 2001. New York, NY

Whitehead, Harry. 1983. *An A-Z of Offshore Oil & Gas*. Second edition. Houston: Gulf Publishing Co.

World Bank 1989. *Republic of Mexico Mining Sector Review.* Trade, Finance and Industry Division, Country Department II. Latin America and the Caribbean Office. Washington, DC.

World Bank 1991. *Tin Sector Strategy Report*. Industry & Energy Dept., Operations Division. Washington, DC.

World Bank 1994. *Market Outlook for Major Energy Products, Metals, and Minerals*. IECIT division. Washington, DC.

World Bank 1996. *Monitoring Environmental Progress: A Report on Work in Progress*. Washington, DC.

World Bank 2000. *Global Commodity Markets: A Comprehensive Review and Price Forecasts*. Washington, DC.

World Bank 2001. *World Development Indicators: 2001*. Washington, DC.

WRI (World Resources Institute). 1995. *World Resources, 1994-95*. New York: Oxford University Press.