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Resource Accounting in Measures of Unsustainability

Challenging the World Bank's Conclusions

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Abstract. The World Bank has recently published a comprehensive study of environmental and resource accounting, covering 103 countries (World Bank 1997a). The study concludes that many Sub-Saharan, Northern African and Middle East countries have had negative 'genuine' saving rates over the last 20 years and therefore fail to pass the test of weak sustainability. This paper argues that the Bank's conclusions depend on a method for computing user costs from resource exploitation that is challenged by two competing ones (the 'El Serafy'-method and the method of Repetto et al.) and is inferior to one of its rivals. Resource rents are re-computed using the 'El Serafy'-method for 14 countries and the Sub-Saharan and Northern African and Middle East regions. The results are that both regions and almost all countries either stop exhibiting signs of unsustainability or their unsustainability can be explained without having recourse to resource accounting. However, for Congo, Ecuador, Gabon, Nigeria, Mauritania and Trinidad and Tobago there is a lesson: These countries did not adequately use the opportunities they were given through their natural resource endowments and should learn from their mistake for the future depletion of their remaining reserves of natural resources.

Key words: accounting, 'El Serafy'-method, genuine savings, natural resources, pollution, sustainability, World Bank

JEL-classification: E22, O13, Q32, Q43

Abbreviations: ENetS – Extended Net Saving; EGS II – Extended Genuine Saving II; EGS II (World Bank) – Extended Genuine Saving II using the World Bank method; EGS II (El Serafy) – Extended Genuine Saving II using the 'El Serafy'-method with discount rate 4% p.a.; EGS II (El Serafy 10% p.a.) – Extended Genuine Saving II using the 'El Serafy'-method with discount rate 10% p.a.

1. Introduction

If sustainability is defined as the capacity to provide non-declining future welfare then, clearly, a reliable measure of sustainability would be of great policy usefulness. In recent years, several studies have been undertaken claiming to provide an admittedly crude measure of *weak* sustainability for single countries or a selection of countries – e.g. Repetto et al. (1989) for Indonesia, Repetto and Cruz (1991)

for Costa Rica, van Tongeren et al. (1993) for Mexico, Bartelmus et al. (1993) for Papua New Guinea, Serôa da Motta and Young (1995) for Brazil, and Pearce and Atkinson (1993), and Hamilton and Atkinson (1996) for several countries. The term 'weak' refers to the fact that, often implicitly, perfect substitutability between man-made, natural and other forms of capital is assumed in both production and utility functions.

World Bank (1997a) is the most comprehensive of these studies, covering 103 countries in total over a period of 25 years. It suggests that the world taken together as well as the high-income countries are safely weak sustainable due to high investments in man-made and human capital. It also suggests that most Sub-Saharan countries and the whole region show signs of unsustainability during the 1980s and 1990s. The same is true for some North African and Middle East countries and the region as a whole who fail to pass the test of weak sustainability from the early 1970s onwards.

This paper critically examines the World Bank (1997a) study. It shows that the Bank's rather strong conclusions crucially depend on a method for computing resource rents that is one of at least three competing ones and is inferior to one of its rivals. Using the so-called 'El Serafy'-method to compute resource rents leads to opposite conclusions for both regions and indeed for most countries that fail to pass the test of weak sustainability according to World Bank (1997a). Thus it is demonstrated that the study does not provide a reliable sustainability indicator and will lead to wrong policy conclusions.

The paper is organised as follows: Section 2 describes the structure of the data and the main conclusions of World Bank (1997a). It also states the welfare theoretic foundations for the Bank's 'genuine savings' indicator of unsustainability. Section 3 discusses competing methods for computing resource rents and argues why using the 'El Serafy'-method is preferable to the Bank's method. Section 4 undertakes empirical sensitivity analysis in computing resource rents according to the 'El Serafy'-method in the calculation of genuine savings for those countries that appeared to be unsustainable according to World Bank (1997a). It shows that the Bank's conclusions are largely reversed if this competing method is used. Nevertheless, a few countries keep on exhibiting signs of unsustainability. For these countries in particular section 5 discusses policy implications. Section 6 concludes.

2. The World Bank Study

The data set underlying World Bank (1997a) consists of savings and accompanying data (World Bank 1997b). Of special interest here is what the Bank calls "Extended Genuine Saving II" (EGS II): gross domestic investment minus net foreign borrowing plus net official transfers plus education expenditures minus depreciation of man-made capital minus resource rents from the depletion of natural resources minus damage caused by CO_2-emissions as a proxy for other pollutants.[1] Current educational spending (e.g. teachers' salaries, expenditures on

textbooks) is considered as an investment in human capital, rather than consumption as in the traditional national accounts. The difference is relevant, since current expenditures make up more than 90% of all educational expenditures (World Bank 1997a, p. 34). For the computation of natural resource rents Word Bank (1997a) includes the following items: oil, natural gas, hard coal, brown coal, bauxite, copper, iron, lead, nickel, zinc, phosphate, tin, gold, silver and forests. Rents are usually computed as price minus average costs times production/harvest, i.e. they are valued at so-called total Hotelling-rent where the more readily available average costs are used as a proxy for the theoretically correct marginal costs. The only pollutant considered are CO_2-emissions which are valued at 20 US$ per metric tonne of carbon. The value is taken from Fankhauser (1995) and is often regarded as a consensus estimate.[2]

Of all the data underlying World Bank (1997a) EGS II is closest to a broad measure of weak sustainability. This result can be derived from dynamic optimisation models as, e.g., in Hamilton (1994, 1996) and Neumayer (1999). While Asheim (1994) and Pezzey and Withagen (1995) have shown that positive genuine saving rates are only a necessary, but not sufficient condition for weak sustainability, ‘persistently negative rates of genuine saving must lead, eventually, to declining well-being’ (World Bank 1997a, p. 28).

Note that because of the underlying optimisation framework efficient resource pricing according to the Hotelling (1931) rule is implicitly assumed: resource rent rises over time at the rate of interest. This leads to some modifications for the ‘keep genuine savings above zero’ rule for an open economy (Hartwick 1996; Asheim 1996). With marginal extraction costs not falling at a rate higher than the interest rate, future resource prices will be higher than current ones, thus providing the resource exporter with improving terms-of-trade. Due to that, the exporter of natural non-renewable resources can have negative genuine savings and still ensure sustainability. The resource importer, on the other hand, faces a future deterioration in her terms-of-trade, so she must save more than would be the case in a closed economy. That is, it is on the non-renewable resource importer to make an extra-adjustment for the growing scarcity of the resource.

In World Bank (1997a) no correction term for anticipated price changes is included on either the resource exporter’s or importer’s side, however. The reason is presumably that the authors consider empirical support for efficient resource pricing to be rather weak and are unsure about the future development of *actual* net resource prices, so that ‘as a default “rule of thumb” for sustainability, simply investing current resource rents is likely to be the prudent course of action’ (Hamilton and Atkinson 1996, p. 4) for both importers and exporters.[3] This disregarding of future price changes is problematic because it contradicts the underlying dynamic optimisation assumptions which were necessary to provide the sustainability foundations of genuine savings in the first place.

World Bank (1997a) assigns all damage from CO_2 to the emitting country. This allocation rule is not compelling. Damage from global warming is caused by

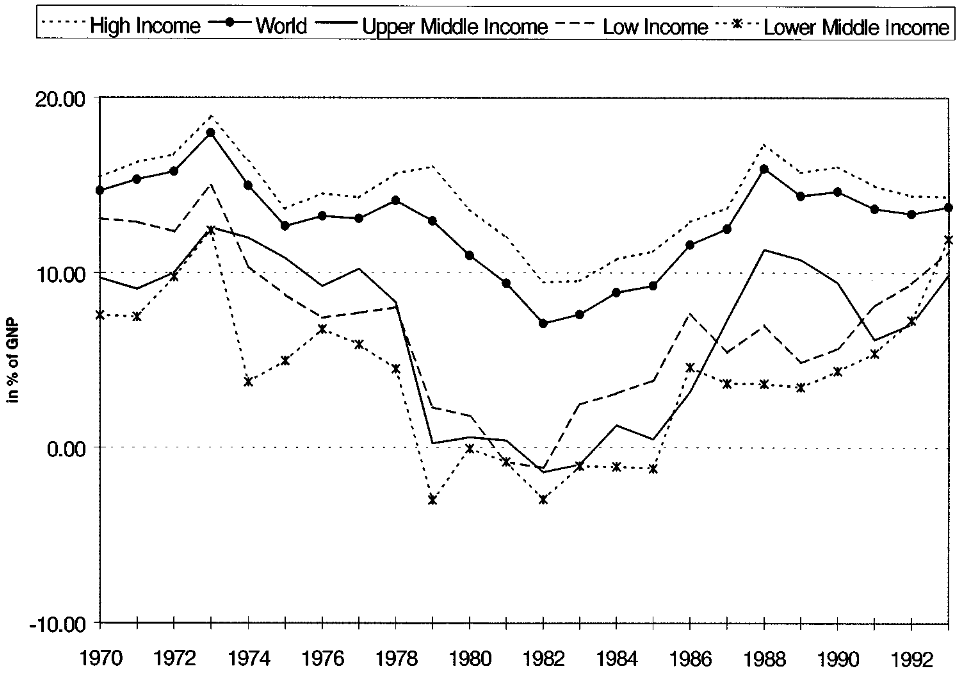
the *accumulated* stock of CO_2 and other greenhouse gases. Developing countries could make a point in claiming that their incremental CO_2-emissions should count less than those from developed countries considering the already existing stock of CO_2 in the atmosphere mainly due to developed country emissions. A closer inspection of the data in World Bank (1997b) reveals, however, that damage from CO_2-emissions plays a negligible role in bringing EGS II rates[4] down below zero. I therefore do not undertake sensitivity analyses for damage from CO_2-emissions.

The years covered in World Bank (1997a) are 1970 to 1994, for some countries only up to 1993. The data set includes 103 countries, which are grouped into income and regional groups (see World Bank 1997b). None of the former or current communist countries is included, for lack of data with acceptable quality. Some of the very small countries are missing as well. Appendix 1 indicates which countries had certain ranges of years with negative EGS II rates.

Figure 1 shows EGS II rates for four different income groups and the world taken together.[5] Keeping in mind that 'where genuine saving is negative, it is a clear indicator of unsustainability' (World Bank 1995, p. 53), it is apparent that for the world taken together and the high income countries in particular there is no indication of unsustainability. All of the other three income groups experience a few years with negative rates, most notably the group of lower middle income countries. The rates are only slightly negative, however, and they are not persistent in the sense that they become positive again in the early and mid-1980s and reach their former level in the early 1990s. It can be concluded therefore that at this level of aggregation no clear signs of unsustainability are apparent.

Figure 2 shows EGS II rates for a selection of five different regions. The highest rates are achieved in East Asia where they usually fluctuate between 10% and 20%. South Asia's EGS II rates are relatively constant around 6–7% and never go negative. For the Caribbean and Latin America the rates decline from 10% in the late 1970s to just below 0% in 1983 from where they have risen again to just over 5% in 1993. More problematic is the region of Sub-Saharan Africa. Its EGS II-rate declined from around 5% in the late 1970s to become negative in 1979, slightly positive in 1980 and turned negative again afterwards where it has stayed for the rest of the period, fluctuating around −5%. Still more problematic is the region of North Africa and Middle East. This region experienced positive rates only in 1972, 1973 and 1986. During the late 1970s and early 1980s it exhibited rates drastically lower than −10%, reaching its climax in 1979 with almost −30%! If persistent EGS II rates are a clear indicator of unsustainability, then Africa and the Middle East appear to be on an unsustainable path.

To analyse what drives EGS II rates to become negative it is best to disaggregate the data still further and look at individual country experiences. I decided, somewhat arbitrarily, to translate 'persistently negative rates' into 'having experienced negative rates for more than 10 years in the period 1970–1994' though not necessarily in a row. 24 out of the total of 103 countries were unsustainable thus defined.



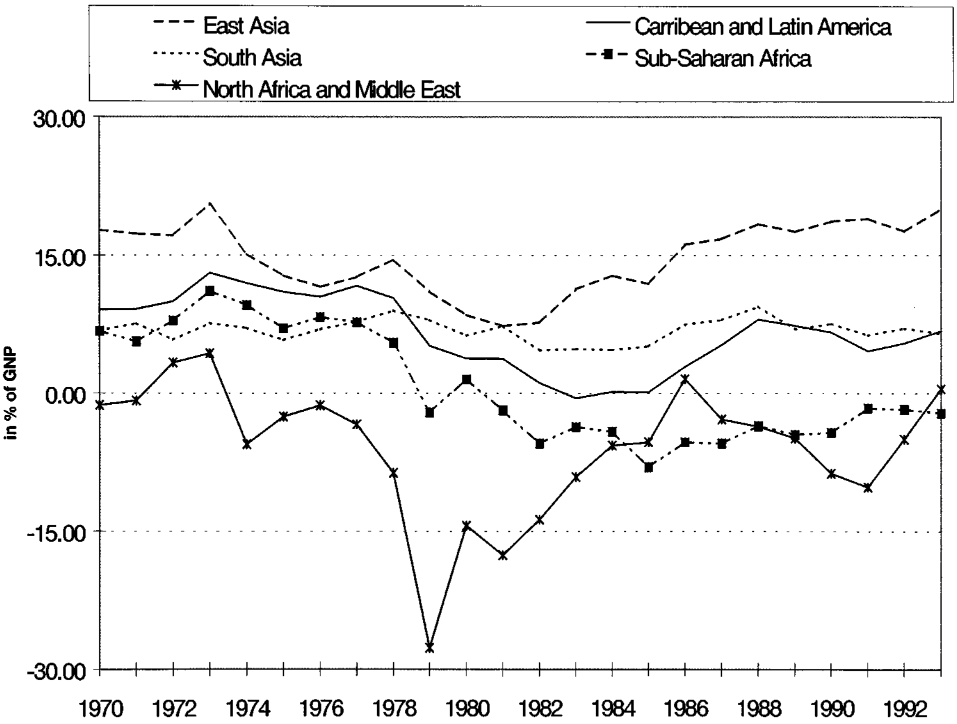
Source: Own computations from World Bank (1997b).

Figure 1. Extended Genuine Saving II rates for income groups.

For 5 out of these 24 countries – Chad, Madagascar, Malawi, Sierra Leone and Uganda – the EGS II rates are very close to and move very closely with the Extended Net Saving (ENetS) rates, where ENetS is defined as gross domestic investment minus net foreign borrowing plus net official transfers minus depreciation of man-made capital plus education expenditures. For these countries, therefore, unsustainability can already be explained without having recourse to taking natural capital into account: they are on an unsustainable path because they eat up their stock of man-made capital. Even taking ENetS as an indicator would detect these countries as unsustainable and looking at EGS II instead would not give major new insights. These countries are therefore excluded from the further analysis.

3. Competing Methods for Computing Resource Rents

Of particular interest is what drives the EGS II rates below ENetS rates for the other countries. Since ENetS minus rents from natural resource depletion minus (negligible) damage from CO_2-emissions equals EGS II, we have to examine in more detail how the numbers for resource rents are generated.



Source: Own computations from World Bank (1997b).

Figure 2. Extended Genuine Saving II rates for regions.

The Bank values resource rents to be deducted from ENetS as

$$(P - AC)\cdot R \tag{1}$$

where *P* is the resource price, *AC* is average cost and *R* is resource depletion. Note that (1) roughly corresponds to total Hotelling rent, except that the more readily available average costs are used instead of marginal costs.

Resource discoveries do not enter the formula. The Bank values discoveries at average discovery costs which are used as a more readily available proxy for marginal costs. Since 'exploration expenditures are treated as investment in standard national accounting' (World Bank 1997a, p. 28) already anyway, there is no correction term for discoveries.

The Bank's method to compute resource rents is just one of at least three. The others I look at here are the so-called 'El Serafy'-method (El Serafy 1989, 1991) and the method of Repetto et al. (Repetto et al. 1989, Repetto and Cruz 1991). The formula for the method of Repetto et al. is:

$$(P - AC)\cdot(R - D)$$

where D is resource discoveries. Note that in this method resource discoveries are valued at $P - AC$, i.e. at net profits and that the correction term can be positive if $D > R$ in the accounting period. Efficient resource pricing according to Hotelling's rule is implicitly assumed. Also note that, strictly speaking, exploration expenditures should be netted out from NNP, if this method is used, in order to avoid partial double counting of resource discoveries.

The formula for the 'El Serafy'-method is:

$$(P - AC)\cdot R\cdot \left[\frac{1}{(1+r)^{n+1}}\right] \tag{2}$$

where r is the discount rate and n is the number of remaining years of the resource stock if production was the same in the future as in the base year, i.e. n is the static reserves to production ratio. If $r > 0$ and $n > 0$, then (2) will produce a smaller deduction term for resource depletion than (1).

(2) is also called the 'user cost' of resource depletion since it indicates the share of resource receipts that should be considered as capital depreciation. Note that no explicit correction term for resource discoveries is needed in this method since discoveries enter the formula via changing n and the formula is computed anew for each year.

The formula for the 'El Serafy'-method is derived from the following reasoning: receipts from non-renewable resource extraction should not fully count as 'sustainable income' because resource extraction leads to a lowering of the resource stock and thus brings with it an element of depreciation of the resource capital stock.[6] While the receipts from the resource stock will end at some finite time, 'sustainable income' by definition must last forever. Hence, 'sustainable income' is that part of resource receipts which if received infinitely would have a present value just equal to the present value of the finite stream of resource receipts over the life-time of the resource.

Defining resource receipts RC as $RC \equiv (P - AC)\cdot R$, then the present value of resource receipts RC at the constant discount rate r over the expected life-time n of the resource stock is equal to:

$$\sum_{i=0}^{n} \frac{RC}{(1+r)^i} = \frac{RC\left[1 - \dfrac{1}{(1+r)^{n+1}}\right]}{1 - \dfrac{1}{1+r}}\,. \tag{3}$$

The present value of an infinite stream of 'sustainable income' SI is

$$\sum_{i=0}^{\infty} \frac{SI}{(1+r)^i} = \frac{SI(1+r)}{r} = \frac{SI}{1 - \dfrac{1}{1+r}}\,. \tag{4}$$

Setting (3) and (4) equal and rearranging expresses *SI* as a fraction of *RC*:[7]

$$SI = RC\left[1 - \frac{1}{(1+r)^{n+1}}\right]. \tag{5}$$

The correction term, representing user cost or the depreciation of the resource stock, would thus be

$$(RC - SI) = RC\left[\frac{1}{(1+r)^{n+1}}\right] = (P - AC)\cdot R\left[\frac{1}{(1+r)^{n+1}}\right]$$

which is the formula in (2). An estimate of the life-time of the resource, *n*, that is the static reserves to production ratio is required. The ‘El Serafy’-method does not presume efficient resource pricing – resource rent growing at the rate of interest according to Hotelling’s rule –, because it is not dependent on an optimisation model. It is an ‘ex post approach, capable of accounting for any entrepreneurial decisions regarding extraction’ (El Serafy 1997, p. 222). As a consequence future resource receipts have to be discounted and the ‘El Serafy’-method requires the selection of a discount rate *r*. If either the life-time of the resource asset, *n*, or the discount rate *r* are quite large, the necessary correction term will consequently be rather small (see equation (2)). Also note that the correction term can never be positive.

Which method for computing natural resource rents should be preferred? Both the World Bank’s method and the method of Repetto et al. can be derived from a dynamic optimisation model. The difference is that to arrive at the World Bank’s method expenditures for resource exploration are modelled as depending on the stock of cumulated discoveries, whereas the method of Repetto et al. can be derived from a model where these expenditures are a function of the total stock of resources. Hamilton (1995, p. 64) shows that modelling discovery expenditures being dependent on the resource stock leads to higher genuine savings than if expenditures depend on the stock of cumulated discoveries.

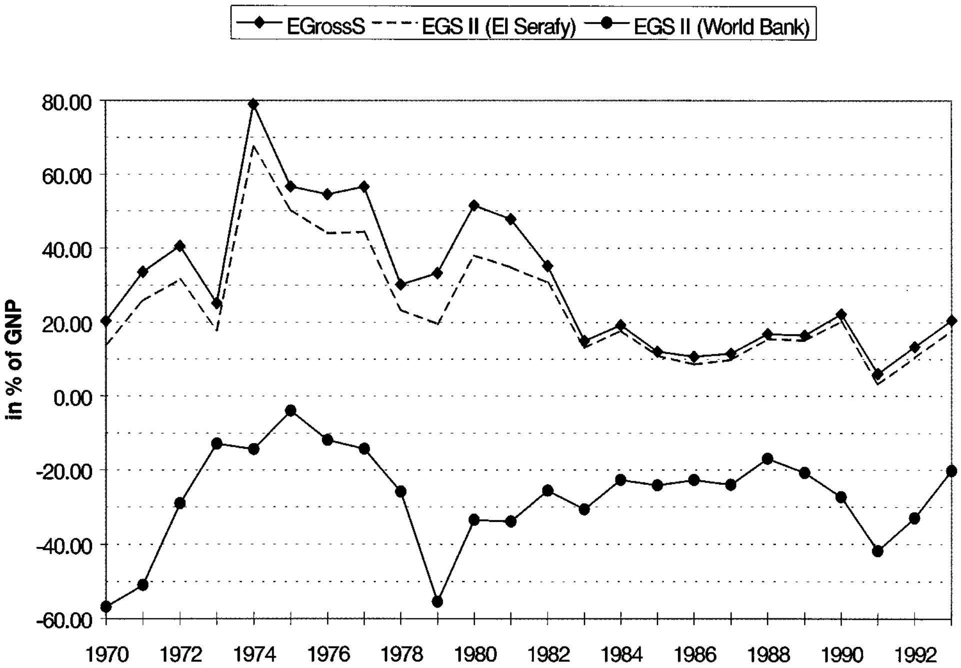
In comparison, the method of Repetto et al. seems to lack direct intuitive appeal. Whereas there does not seem to exist a good reason for assuming that exploration costs depend on the total stock of a resource, it makes much sense to assume that resource exploration costs depend on the stock of past discoveries as the World Bank’s method does. This is because later discoveries should be more expensive than earlier ones if the easy to find reserves are discovered first – which we would expect in a dynamic optimisation framework. On the other hand, the two methods are obviously linked since resource discoveries both increase the stock of past discoveries and the resource stock. Overall I would say that on theoretical grounds there are more good reasons in favour of the World Bank’s method.

The ‘El Serafy’-method, on the other hand, can be argued to be superior to the Bank’s method. This is for three reasons: one is that it is not derived from a dynamic optimisation model. None of the data the Bank uses are guaranteed

to be the ones that would be generated if a country's economy developed along the optimal path and the Bank does not attempt to estimate any shadow values. Actually, since, as mentioned already, the Bank excludes future terms-of-trade effects in computing EGS II, it even implicitly excludes efficient resource pricing. Hence, to be consistent, it is better to use a method for computing resource rents that does not presume that the underlying data are optimal values either. Interestingly, in Atkinson et al. (1997, p. 60f.) the same authors on whose work the World Bank (1997a) study is mainly built upon, admit that since 'there is little evidence for efficient pricing of resources in the ground', it 'may be advisable to value resource depletion as a user cost with a non-zero discount rate' according to the 'El Serafy'-method.

Second, in contrast to the World Bank method the 'El Serafy'-method counts only part of resource rents as capital depreciation, but the rest as sustainable income which makes more sense. With the World Bank method, a country completely dependent on resource exploitation, an extreme case of Saudi-Arabia, could never have positive EGS II as all resource rents are counted as capital depreciation and could therefore never be sustainable. Hartwick (1996) has shown, however, that a resource-dependent country can ensure WS in investing parts of its resource rent into alternative forms of capital.

Third, the Bank's method lacks intuitive appeal if one looks at the EGS II rates it generates for certain countries. Take Saudi Arabia as an example: Figure 3 shows the country's ENetS rates together with EGS II rates calculated with the Word Bank method (EGS II (World Bank)) and EGS II rates calculated with the 'El Serafy'-method (EGS II (El Serafy)). EGS II measures increases or decreases in the total stock of a nation's capital. According to EGS II (World Bank) Saudi Arabia has had persistent negative rates (usually lower than −20%) for the whole period of accounting. This does not make any sense since it would mean that almost all of Saudi-Arabia's once existing total capital stock would have been eaten up and the country's economy would be doomed to collapse. If we assume for simplicity that Saudi Arabia's capital stock is not tremendously higher than the average of Middle East countries, then it has a total capital stock (manufactured plus natural) of approximately 85,000$ per capita according to World Bank (1997a, p. 11). With a GNP per capita of around 7,800 US$, Saudi Arabia would have lost almost all its capital, if it really had had an average negative genuine saving rate of about −30% of GNP over a period of 24 years as the World Bank figures indicate. Why did it not collapse? Mainly because part of the resource rent should properly count as income and not as capital depreciation and also because during the accounting period more oil and natural gas wells were discovered that boosted the nation's capital stock. As we will see in the next section, if the 'El Serafy'-method is used instead for computing net depreciation of the natural resource stock then Saudi-Arabia turns out to exhibit positive EGS II rates: the country's capital stock has increased instead of diminished to negligible quantities as suggested by the World



Source: Own computations from World Bank (1997b) and sources indicated in Appendix 2.

Figure 3. Sensitivity analysis for resource rents of Saudi Arabia.

Bank's method. This makes much more intuitive sense considering how well off Saudi Arabians are.

I do not claim that the 'El Serafy'-method is without problems. One of its shortcomings lies in its assumption about constant resource receipts, which has been one of the most frequently raised criticisms against the method (e.g. Hartwick and Hageman (1993, p. 222), Aaheim and Nyborg (1995, p. 63), Brekke (1997, p. 524)). Note, however, that since World Bank (1997a) assumes constant net resource prices as well, part of this criticism is irrelevant for the choice between the World Bank's method and the 'El Serafy'-method. Furthermore, the 'El Serafy'-method can use readily available average costs without apology. The World Bank's method, on the other hand, has to commit the mistake of inconsistency: for practical reasons it has to rely on average costs, but this contradicts once more the underlying assumption of efficient resource pricing according to the Hotelling rule which is defined in marginal cost terms.[8]

4. Computing Resource Rents According to the 'El Serafy'-method

In the following sensitivity analysis resource rents have been computed with the 'El Serafy'-method instead of the Bank's method for the countries that have been

classified as unsustainable. Which resources do we need to look at for this analysis? Table I provides the answer. It shows that for Algeria, Bolivia, Congo, Ecuador, Gabon, Iran, Nigeria, Saudi Arabia, Trinidad and Tobago, and Venezuela the dominating force is oil and natural gas. Their share is always more than 90% with the exception of Bolivia for which tin is also important. For Papua New Guinea the dominating resources are copper and gold, for Zambia it is copper, for Jamaica it is bauxite, for Mauritania iron ore. For Nepal, Haiti, and Ghana forestry represents a major share of resource rents. For Ghana it is also gold. For the more important countries it is clearly rents from oil and natural gas that dominate.

The following sensitivity analysis covers oil, natural gas, bauxite, copper, gold, iron ore and tin. Appendix 2 describes the sources of data for computing user costs according to the 'El Serafy'-method. Forestry was excluded due to the many difficulties in getting reliable data. It follows that no sensitivity analysis could be undertaken for Nepal and Haiti and for parts of Ghana's resource rents. A relatively low discount rate of 4% p.a. was applied following the rate which World Bank (1997a) uses for wealth estimations.

The sensitivity analysis reveals a number of things:

(1) Those countries with huge reserves of resources relative to their production and positive ENetS rates throughout stop having negative EGS II rates (El Serafy) altogether or have only one year with a negative rate. This applies to Algeria, Iran, Papua New Guinea, Saudi Arabia, and Venezuela. (As an example refer back to Figure 3 for Saudi Arabia.) This was to be expected since high reserves to production ratios (a high n in equation (2)) depress the user costs of resource depletion. This is because, for a given resource production, a smaller share of the total resource stock is used up.

(2) The unsustainability of some countries with temporary negative ENetS rates can be explained without taking recourse to EGS II rates. This applies to Bolivia and Jamaica, which for every year of negative EGS II rates (El Serafy) have negative ENetS rates as well. It also applies to Ghana which has only one year (1987) of both a positive ENetS-rate and a marginally negative EGS II-rate (El Serafy). For Zambia EGS II rates (El Serafy) are rather close to and move rather close with ENetS rates as well. Zambia has six years of slightly positive ENetS rates and slightly negative EGS II rates (El Serafy), however.

(3) Remain the cases of Congo, Ecuador, Gabon, Nigeria, Mauritania, and Trinidad and Tobago. These countries share a similar experience: although EGS II rates (El Serafy) are considerably higher than EGS II rates (World Bank), in a number of years EGS II rates (El Serafy) are negative while ENetS rates are still positive. For Congo this is true for four years, for Ecuador for seven years, for Gabon for four years, for Nigeria for six years, for Mauritania for three years and for Trinidad and Tobago for seven years. The reasons for this divergence are similar for these countries: they all have relatively low oil reserves to production ratios, with the exception of Mauritania which produces iron ore.[9] In addition, usually in the 1980s their production increased, while their reserves either remained

Table I. Share of single natural resources of total resource rents.

Country	1970–74	1975–79	1980–84	1985–89	1990–94
Share of Oil and Natural Gas of Rents in %					
Algeria	96.32	98.85	99.54	99.35	99.35
Bolivia	53.52	64.08	81.33	72.58	68.15
Congo	90.34	97.49	99.49	99.58	100.00
Ecuador	97.94	99.92	99.79	98.01	98.91
Gabon	99.76	99.99	99.99	99.92	99.99
Iran	99.71	99.76	99.74	98.81	99.23
Nigeria	99.77	99.59	99.93	98.27	95.17
Saudi Arabia	100.00	100.00	100.00	100.00	100.00
Trinidad and Tobago	100.00	100.00	100.00	100.00	100.00
Venezuela	94.10	97.81	98.94	97.69	96.94
Share of Copper of Rents in %					
Papua New Guinea	55.18	81.84	61.42	59.09	48.29
Zambia	96.50	91.29	81.15	80.18	81.45
Share of Bauxite of Rents in %					
Jamaica	100.00	100.00	100.00	100.00	100.00
Share of Forestry of Rents in %					
Nepal	98.92	81.48	85.02	99.45	100.00
Haiti	80.09	80.44	92.27	100.00	100.00
Ghana	0.00	9.34	39.72	69.25	75.80
Share of Gold of Rents in %					
Ghana	79.64	55.95	48.97	26.91	20.65
Papua New Guinea	43.09	17.38	37.20	40.20	31.16
Share of Iron Ore of Rents in %					
Mauritania	91.93	97.19	100.00	100.00	100.00
Share of Tin of Rents in %					
Bolivia	29.00	27.98	12.81	5.06	8.06

Source: Own computations from World Bank (1997b).

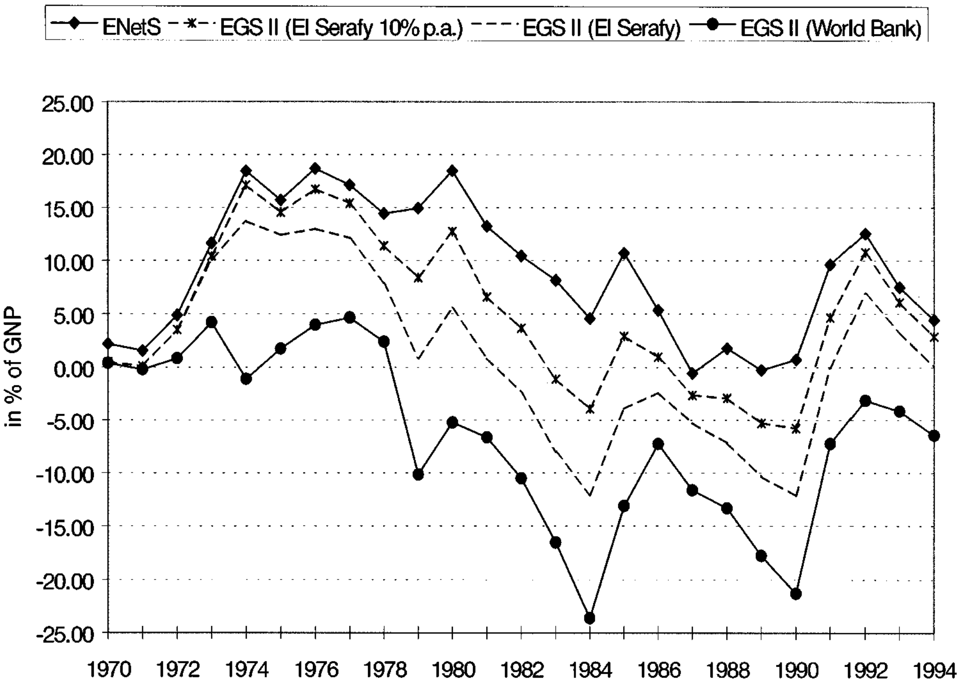
constant or even declined which further depressed their reserves to production ratio. Because of that the user costs from oil depletion calculated via the 'El Serafy'-method are high (although not as high as according to the Bank's method, of course). Interestingly, all these countries with the exception of Gabon exhibit high reserves to production ratios for natural gas over the period 1970–1994, i.e. their natural gas reserves have not been significantly exploited so far.[10] This can provide some hints as to how past mistakes can be avoided in the future as will be argued in the next section. Before doing so let us ask first, however, whether we can conclude that for these six countries the failure of passing the test of weak sustainability can be reliably detected only with EGS II rates (El Serafy), whereas their ENetS rates would misleadingly suggest that these countries are weakly sustainable.

The answer is no, at least not in general. This is because in computing EGS II rates (El Serafy) a rather low rate of discount (4% p.a.) was deliberately chosen so as to provide a conservative estimate of the divergence from the EGS II rates (World Bank). Usually, real rates of return, especially in developing countries are much higher than 4% p.a. For further analysis I have therefore analysed the effects of choosing a discount rate of 10% p.a. Looking back at equation (2) reveals that a high discount rate (r) depresses user costs. This is because a smaller share of resource receipts has to be invested in an alternative asset in order to provide a sustainable alternative income stream if the rate of return on this investment is higher.

For Congo and Nigeria the EGS II rates (El Serafy) move so close with the ENetS rates if a discount rate of 10% p.a. is used that hardly any additional information is revealed by looking at EGS II (El Serafy 10% p.a.) rather than ENetS. Gabon stops exhibiting any signs of unsustainability if EGS II (El Serafy) is calculated with the higher discount rate. The same is true for Mauritania except for one year in which her ENetS-rate is also negative. For the two remaining countries the picture is less clear-cut. Ecuador has only two years with negative ENetS rates, but still six years of negative EGS II rates (El Serafy 10% p.a.) – see Figure 4 below. The gap between EGS II rates (El Serafy 10% p.a.) and EGS II rates (World Bank) is quite large (up to about 20 percentage points in 1984), but it is not always enough to bridge the gap between ENetS rates and EGS II rates (El Serafy 10% p.a.). The same is basically true for Trinidad and Tobago which has four negative EGS II rates (El Serafy 10% p.a.), but only two negative ENetS rates. Especially for these two countries a lesson can be learned from their gap between ENetS and EGS II (El Serafy), whether calculated at 4% p.a. or 10% p.a., and it is this the next section focuses on.

5. Policy Implications

The divergence between ENetS rates and the EGS II rates (El Serafy), that is detectable even with a discount rate of 10% p.a., can provide some hints for better

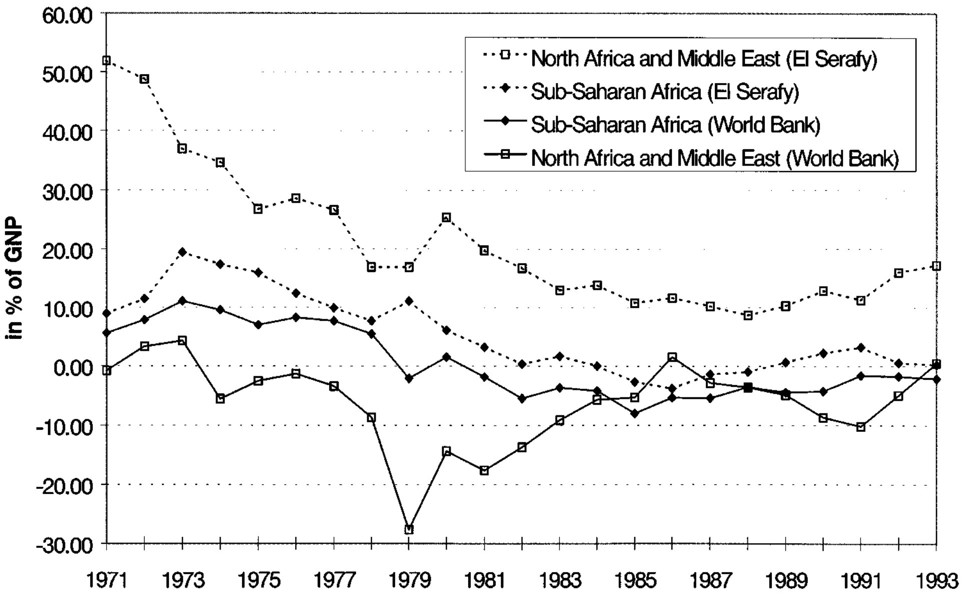


Source: Own computations from World Bank (1997b) and sources indicated in Appendix 2.

Figure 4. Further sensitivity analysis for Ecuador.

future resource management. What the divergence suggests is that these countries in the past did not adequately use the opportunities they were given through their oil endowment, or in the case of Mauritania iron ore endowment, to build up and maintain man-made and human capital in exchange for resource depletion. They should learn from their mistake for the future depletion of their as yet hardly exploited natural gas reserves or, in the case of Mauritania, the still considerable iron ore reserves.[11]

This is one of the rare points where this paper's analysis is in harmony with the basic reasoning of the World Bank's conclusions: 'The depressed rates of genuine saving (...) represent an opportunity not seized. (...) [I]t is often the gross saving effort that is insufficient in these countries, which points the finger squarely at broader macroeconomic policies' (World Bank 1997a, p. 35). The fundamental message of this conclusion is not confined to Congo, Ecuador, Gabon, Nigeria, Mauritania, and Trinidad and Tobago, however. Even for countries with very high reserves to production ratios and hence no indication of a failure to pass the test of weak sustainability, a large divergence between ENetS rates and EGS II rates (El Serafy) suggests 'that due prudence is not being followed – that some amount of



Source: Own computations from World Bank (1997b) and sources indicated in Appendix 2.

Figure 5. Sensitivity analysis for Sub-Saharan Africa, and North Africa and Middle East.

the national [natural resource, E.N.] wealth is simply consumed ... ' (World Bank 1997a, p. 35).

Finally, let us have a look at some aggregate graphs. Figure 5 compares EGS II rates (World Bank) for Sub-Saharan Africa and for North Africa and Middle East to their EGS II rates (El Serafy) with a discount rate of 4% p.a. Whereas Sub-Saharan Africa has 14 years of negative EGS II rates following the World Bank method, there are only four years with slightly negative rates if resource rents are computed with the 'El Serafy'-method. The latter paints a picture of much less gloom for the region.[12]

The reversal in conclusion about the sustainability performance of a region is even drastically stronger in the case of North Africa and Middle East. Whereas EGS II rates (World Bank) suggest that this region is clearly unsustainable with only three years of positive rates, the graph of EGS II rates (El Serafy) paints a completely different picture: North Africa and Middle East never fail to pass the test of weak sustainability and, better still, exhibit quite strong EGS II rates (El Serafy) that are above 20% in eight years and between 10% and 20% for the rest of the period with the exception of one year! The policy conclusions from the two methods are completely different: whereas the World Bank method suggests that North African and Middle East countries endanger the welfare of their future populations, the 'El Serafy'-method suggests that there is no reason to worry about

sustainability since enough of the resource rents are invested in man-made and human capital.

6. Conclusion

The World Bank (1997a) study claims that many Sub-Saharan and North African and Middle East as well as some countries from other regions have failed to pass the test of weak sustainability. This paper has shown in a sensitivity analysis that this conclusion crucially depends on the specific method the World Bank uses to compute resource rents. In calculating resource rents with this method the Bank applies an inconsistent methodology: on the one hand, its method for resource accounting assumes efficient resource pricing as a necessary consequence of the underlying dynamic optimisation framework that provides the welfare theoretic foundations for genuine savings. On the other hand, World Bank (1997a) implicitly rejects efficient resource pricing in ignoring future terms-of-trade effects according to the Hotelling (1931) rule. Using Saudi Arabia as an example, it was shown that this inconsistency leads to the counter-factual conclusion that the country has depleted its capital to an extent that its inhabitants should be severely impoverished which they are clearly not.

As an alternative the 'El Serafy'-method was therefore employed which was argued to be superior to the World Bank's method since it does not depend on efficient resource pricing and leads to intuitively more plausible conclusions. If this alternative method is used with a relatively low discount rate of 4% p.a., Sub-Saharan Africa does not exhibit persistent negative rates of genuine saving anymore and the region of North Africa and Middle East turns out to be a strong genuine saver. This finding holds basically true on a disaggregated level as well for most countries that were detected by World Bank (1997a) as unsustainable: either they do not fail to pass the test of weak sustainability anymore or their unsustainability can be explained with negative extended net saving rates alone, i.e. without taking recourse to resource depletion.

As mentioned already, I do not claim that the 'El Serafy'-method is perfect. In addition to the points discussed already comes the fact that the 'El Serafy'-method can produce different figures using different discount rates and it is far from clear what the 'right' rate is. Another problem is that very often reserve data of resources are much less reliable than production data and sometimes completely missing. Given the crucial role that n, the static reserves to production ratio, plays in calculating user cost, this certainly represents a weakness and a lot more effort would be needed to establish reliable and verifiable reserve data. Maybe therefore future research can find a better method for computing net depreciation of the natural resource stock. What matters for the analysis in this paper is that I have argued that the 'El Serafy'-method is better than the World Bank's method.

If the World Bank's (1997a) results are taken serious as a reliable indicator of unsustainability, the Bank itself and other institutions will be tempted to follow

wrong policy conclusions for the wrong countries. One policy conclusion Atkinson and Hamilton (1996, p. 4f. and 14) and Atkinson et al. (1997, p. 114) tentatively suggest, is making aid conditional for developing countries who fail to pass the test of weak sustainability in order to bring them (back) on a sustainable path.[13] As this paper has made clear, it is much more difficult to detect these countries and the reason for their failure to be sustainable is likely to stem from inadequate extended net savings rather than from wasting the receipts from resource depletion.

Many other critical aspects of the World Bank (1997a) study have not been scrutinised in this paper. For example, it is debatable whether valuing CO_2-emissions with 20US$ per tonne of carbon is sufficient to account for damage caused by greenhouse gases and, particularly, by other pollutants. In doing so, more might have been left out than has been included. Also, the coverage of renewable resources would need to be extented in order to arrive at a comprehensive genuine saving measure. Forests are an important renewable resource, but not the only one. If possible, resources like water, soil, fish and, more generally, biodiversity should be included.

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Notes

1. The term 'genuine' was introduced by Hamilton (1994) to distinguish it from traditional net saving measures which included only depreciation of man-made capital.
2. All values are in current US$. For more information on the data see World Bank (1997a) and Kunte et al. (1997), its technical documentation.
3. Kirk Hamilton from the Bank's Environment Department is one of the main authors of World Bank (1997a).
4. In the following saving rates are always defined as saving divided by GNP.
5. Note that for the saving rates of all income groups and of all regional groups, countries enter the numerator with their savings and the denominator with their GNP, i.e. big countries tend to dominate the aggregate figures.
6. The same reasoning applies to renewable resources if harvesting exceeds natural regeneration.
7. By assumption, RC accrue at the beginning of the accounting period. If RC accrue at the end of the accounting period, then $n+1$ in equation (5) would be replaced by n.
8. I am grateful to an anonymous referee for drawing my attention on this point.
9. Over the period 1970–1994, the approximate average oil reserves to production ratios are as follows: Congo 27 years, Ecuador 21 years, Gabon 17 years, Nigeria 27 years, Trinidad and Tobago 9 years. Mauritania's average iron ore reserves to production ratio is 34 years.

10. Congo > 100 years, Ecuador > 100 years, Nigeria > 80 years, Trinidad and Tobago > 70 years. Extremely high reserves to production ratios in years of unusually low production have been excluded in calculating the average in order to provide a conservative estimate.
11. Unfortunately, their natural gas reserves are smaller in terms of share of world reserves than their oil reserves: Congo has an average share of world natural gas reserves over the period of 1970–1994 of about 0.05% as opposed to about 0.1% share of world oil reserves; the analogous figures for Ecuador are 0.12% as opposed to 0.3%; 0.07% as opposed to 0.17% for Gabon; 1.87% as opposed to 2.35% for Nigeria. Only Trinidad and Tobago has higher natural gas than oil reserves (0.31% versus 0.11%).
12. Note that the EGS II-rate (El Serafy) calculates resource rents according to the 'El Serafy'-method only for six out of a total of 30 countries. The rest enters the EGS II-rate (El Serafy) with their resource rents still computed according to the World Bank method. If resource rents for the other 24 countries had also been calculated according to the 'El Serafy'-method (especially for such important resource producers as Côte d'Ivoire and South Africa) then, no doubt, the EGS II-rate (El Serafy) would have been positive throughout the period.
13. It is unclear whether conditionality is supposed to apply to existing development aid or additional aid. Usually, the mentioned authors simply speak of aid in general, but Atkinson et al. (1997, p. 207) propose 'a possible role for *additional* bilateral aid in assisting, where needed, the fulfilment of genuine savings requirements' (my emphasis).

Appendix 1: Frequency of Negative Extended Genuine Saving II Rates

Out of 25 possible years, the following countries had negative EGS II rates for

0 years:	45 countries in total: All high income countries, plus Antigua and Barbuda, Barbados, Belice, Brazil, Burkina Faso, China, Colombia, Costa Rica, Dominican Republic, Grenada, India, Israel, Malaysia, Morocco, Philippines, South Africa, Sri Lanka, Thailand, Turkey
1–3 years:	13 countries in total: Argentina, Greece, Guinea-Bissau, Jordan, Kenya, Mali, Mauritius, Pakistan, Paraguay, Togo, Tunisia, Uruguay, Zimbabwe
4–6 years:	8 countries in total: Cameroon, Egypt, El Salvador, Indonesia, Mexico, Myanmar, Namibia, Peru
7–10 years:	13 countries in total: Bahrain, Benin, Central African Republic, Chile, Côte d'Ivoire, Gambia, Guatemala, Guinea, Niger, Rwanda, Senegal, Suriname, Syria
> 10 years:	24 countries in total: Algeria, Bangladesh, Bolivia, Burundi, Chad, Congo, Ecuador, Gabon, Ghana, Haiti, Iran, Jamaica, Madagascar, Malawi, Mauritania, Nepal, Nigeria, Papua New Guinea, Saudi Arabia, Sierra Leone, Trinidad and Tobago, Uganda, Venezuela, Zambia

Appendix 2: Sources of Data for Computing User Costs According to the 'El Serafy'-method

To compute user costs for resource depletion according to the 'El Serafy'-method, one needs to establish four different terms:

- $P - AC$, net resource price
- R, resource depletion (production)
- r, the discount rate
- n, the number of years reserves would last at current production rates (reserves to production ratio).

($P - AC$) was computed by dividing resource rents in World Bank (1997a) through production. If not stated otherwise in the text, the discount rate was assumed to be 4% p.a. This is the rate World Bank (1997a) uses for wealth estimations (for a justification see Kunte et al. 1997, p. 8f.).

Oil

Production figures covering the period 1970–1994 came from British Petroleum (1980, 1986, 1997) with the exception of Bolivia and Congo. For Congo production data for 1970–1979 came from Petroleum Publishing (various years) and from British Petroleum (1986, 1997) for 1980–1994. For Bolivia production for 1970–1994 was taken from Financial Times Oil and Gas (various years).

With the exception of Bolivia, Congo, and Trinidad and Tobago proven reserves were taken from OPEC (1979) for the years 1970–1979 and from OPEC (1997) for the years 1980–1994. For Bolivia, Congo, and Trinidad and Tobago reserves were taken from Energy Information Administration (1991) for the years 1970–1991 and from Petroleum Publishing (various years) for 1992–1994.

Natural Gas

Production data covering the period 1970–1994 came from OPEC (various years) with the exception of Congo, Ecuador and Gabon. For Ecuador production data for 1991–1994, for Gabon production data for 1971–1973 and for Congo production data for the period 1970–1994 came from United Nations Yearbook (various years). For 1970–1990 production data for Ecuador and for 1974–1994 production data for Gabon came from OPEC (various years).

With the exception of Bolivia and Congo proven reserves were taken from OPEC (1980) for 1971–1979 and from OPEC (1997) for the years 1980–1994. For Bolivia and Congo proven reserves for the period 1970–1994 were taken from Petroleum Publishing (various years).

Non-energy Resources

For bauxite, copper, gold and tin production data for 1981–1994 came from World Bureau of Metal Statistics (1991, 1997). For bauxite, copper and tin data for 1970–1980 came

from World Bureau of Metal Statistics (1975, 1979, 1984). For gold data for 1970–1980 came from Financial Times Mining (various years). For 1970–1994 iron ore production data came from United Nations (1977, 1986, 1996).

Time-series individual country data for proven reserves of non-energy resources are notoriously difficult to get hold of. A couple of short-cut formulas had to be applied therefore where direct data were not available. The bias in the data is likely to be small, however, since according to Bill Kirk from the U.S. Bureau of Mines non-energy reserves tend to be relatively constant over time.

Bauxite reserve data for Jamaica came from U.S. Bureau of Mines (various years) with the help of the Bureau's bauxite specialist Pat Plunkert. Copper reserve data for Zambia came from U.S. Bureau of Mines (various years). For Papua New Guinea individual country reserve data for copper could only be established for the years 1978–1981 and 1990. For 1976–1977 reserve data were approximated by world reserves in these years times the 1978 share of the country's reserves of world reserves. The same applies to 1982–1986 using the 1981 share and to 1987–1989 and 1991–1994 using the 1990 share. Individual gold reserve data for Ghana and Papua New Guinea could not be established. For Ghana gold reserves for 1970–1994 were approximated by world reserves in these years times the 1994 share of the country's reserves of world reserves which was provided by George J. Coackley, the U.S. Bureau of Mines' country expert for Ghana. For Papua New Guinea it had to be assumed, somewhat arbitrarily, that her reserve share of world gold reserves for the years 1976–1994 were equal to her production share of world gold production in the corresponding years. Iron ore reserve data for Mauritania are due to personal information from Bill Kirk from the U.S. Bureau of Mines. Tin reserve data for Bolivia for 1978–1994 came from U.S. Bureau of Mines (various years). For 1970–1977 reserve data were approximated by world reserves in these years times the 1978 share of the country's reserves of world reserves. Where necessary, world reserves were taken from U.S. Bureau of Mines (various years).

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