6. A critical appraisal of genuine savings as an indicator of sustainability

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INTRODUCTION

Chapters 3, 4 and 5 have introduced the tradition of green national accounting that has now become well established. The basic principles of this tradition are commonly understood by most practitioners to involve accounting for the consumption and accumulation of produced, human and natural capital, assuming the different capital stocks are infinitely substitutable (weak sustainability). One particular indicator that shares this basis and has been the subject of considerable attention and data gathering over the last decade is genuine savings (hereafter GS). In this chapter, we introduce and critically appraise GS.

THE BASIC MEANING OF GENUINE SAVINGS

GS sets out to measure whether we are dis-saving. That is, whether we allow depreciation of total capital to exceed investment in all forms of capital. The term 'genuine' was coined by Hamilton (1994) to reflect the fact that GS includes all forms of capital, not just produced capital.[1] In common with the wider green national accounting literature, GS traces its roots back to the work of neoclassical economists Robert Solow (1974) and John Hartwick (1977), who were concerned with modelling a development path in which social welfare or well-being does not decline in an economy exploiting a non-renewable resource. The problem is one of maximising the present value of social welfare over all time, given a range of simplifying assumptions that will be critically discussed below. Solving this maximisation problem yields green net national product or gNNP, which is equal to society's consumption plus the sum of net changes in all the capital stocks valued at their shadow prices. These shadow prices are the prices that would exist in an inter-temporally efficient economy without externalities (this is one such assumption):

$$\begin{aligned} \text{gNNP} = {} & \text{consumption} + \text{net investment in produced capital} \\ & - \text{net depreciation of natural capital} \\ & + \text{investment in human capital.} \end{aligned} \tag{6.1}$$

Subtracting consumption leaves us with net changes in all the capital stocks valued at their shadow prices, which is GS. Without pursuing a formal derivation (see Hamilton and Clemens, 1999):

$$\begin{aligned} \text{GS} = {} & \text{net investment in produced capital} \\ & - \text{net depreciation of natural capital} \\ & + \text{investment in human capital.} \end{aligned} \tag{6.2}$$

In what equates to a modification to the so-called Hartwick rule,[2] the aim of the sustainability planner is to keep GS above or equal to zero. This is a necessary (but not sufficient) condition for ensuring sustainability under the weak sustainability paradigm. If GS is persistently below zero, then the economy is not sustainable, since future utility must be below current utility at some point (Hamilton and Clemens, 1999). Keeping GS greater than or equal to zero is necessary but not sufficient to ensure sustainability. Asheim (1994) and Pezzey and withagen (1995) showed that, if the economy has had persistently negative GS in the past, then positive GS at some later point in time is insufficient to guarantee sustainability. But the sustainability planner does not have the luxury of hindsight. This means that GS is at best a one-sided indicator. We will reprise this issue below.

EMPIRICAL ESTIMATES OF GENUINE SAVINGS

Pearce and Atkinson (1993) produced initial GS estimates for 18 countries. Since then, the GS mantle has very much been assumed by the World Bank (see, for example, World Bank 2003), which now regularly publishes a comparatively comprehensive GS measurement exercise for over 150 countries.[3] In simplified form, the World Bank operationalises GS, which it now calls 'Net Adjusted Savings' – as follows:

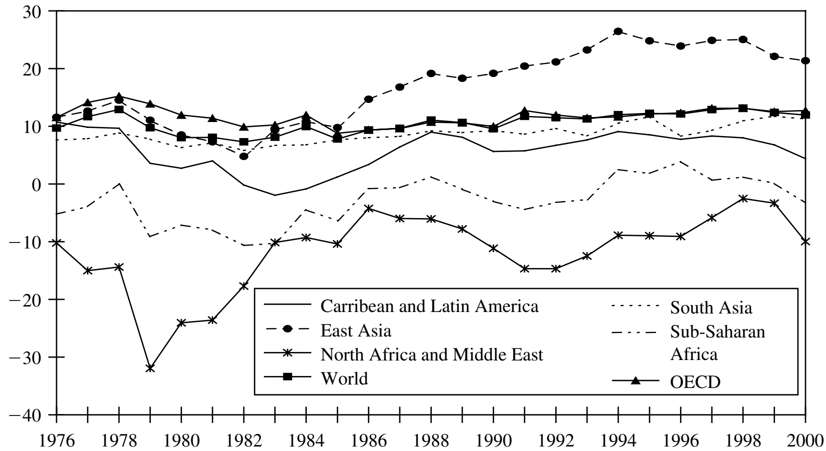
$$\begin{aligned} \text{GS} = {} & \text{investment in man-made capital} - \text{net foreign borrowing} \\ & + \text{net official transfers} - \text{depreciation of man-made capital} \\ & - \text{net depreciation of natural capital} \\ & + \text{current education expenditures} \end{aligned} \tag{6.3}$$

- Investment in produced capital, net foreign borrowing and net official transfers are obtained from the national accounts. Although depreciation of produced capital is not, estimates can be derived from data on produced capital formation. The World Bank uses estimates from the United Nations Statistics Division.
- Net depreciation of natural capital can be divided at a basic level into resource extraction on the one hand and environmental pollution on the other. The World Bank estimates resource extraction for a range of fossil fuels (oil, natural gas, hard coal and brown coal), minerals (bauxite, copper, iron, lead, nickel, zinc, phosphate, tin, gold and silver), and one renewable resource (forests). Depreciation of these resources is computed as the product of price minus average costs of extraction multiplied by the volume of extraction:

$$(P-AC)^*R \tag{6.4}$$

  where P is the resource price, AC is average cost and R is the volume of extraction (in the case of a renewable resource, R represents harvest beyond natural regeneration). Environmental pollution is conceptualised as the use of sink capacity in order for it to be equivalent to capital depreciation. Until recently, environmental pollution was taken to be the estimated damage cost of carbon dioxide emissions where each ton of carbon emitted is valued at US$20 per metric tonne of carbon (from Fankhauser, 1995). In its most recent estimation (2003), it added the damage costs of particulates in the air.
- Investment in human capital is calculated as net educational expenditure. This includes both capital expenditure as well as current expenditure that are counted as consumption rather than investment in the traditional national accounts. This is certainly rather crude, but it is difficult to see how investment in human capital could be estimated otherwise for so many countries over such a long time horizon. Dasgupta (2001a, p. C9 f.) argues that it is an overestimate since human capital is lost when people die. But part of the human capital stock might be passed on when people die or, to be precise, leave the workforce. In any case, such a correction would be difficult to undertake.

Figure 6.1 shows estimated GS for the major world regions and global GS between 1976 and 2000. Global GS and GS in the OECD countries, East Asia and South Asia have always been positive. In practicality then, these regions and the world as a whole have passed the one-sided GS test: they have apparently not been unsustainable over the past 25 years or so. Latin

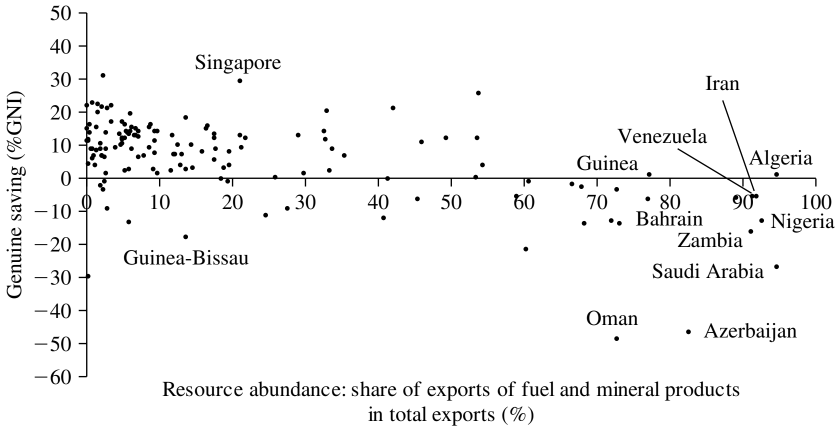


Source: World Bank (2004).

Figure 6.1 Genuine savings rates as a percentage of GNP

America and the Caribbean had negative GS for a time during the early 1980s, but the worst savers have been Sub-Saharan Africa, North Africa and the Middle East. In Sub-Saharan Africa, GS has been negative since the early 1980s. In North Africa and the Middle East, they have always been negative.

One conclusion we can draw from this data is that the regions with the greatest natural resource extraction are also the poorest performers in terms of GS (Neumayer, 2003). This is also true at the national level of analysis. Figure 6.2 plots time-averaged national GS rates against an indicator of resource abundance: the share of fuel and mineral exports in total exports. With the exception of Algeria and Guinea, for whom GS was just above zero for the period 1970–2001, every country with an average share – of fuel and mineral exports in total exports of over 60 per cent had negative GS. In contrast, most resource-poor countries, especially the cluster of countries with an average share of fuel and mineral exports in total exports of under 20 per cent, had positive GS. In Sub-Saharan Africa, it must also be said that net produced capital investment is often negative too. In other words, the total 'man-made' wealth of these countries is also decreasing, and the World Bank's estimates of net natural capital depreciation simply worsen the situation. This is the case in Guinea-Bissau, for example. The surprising element of the World Bank's results is that some heavy resource extractors appear more unsustainable than intuition would suggest (Neumayer, 1999, 2003). Saudi Arabia is the clearest example of this. It is



Source: World Bank (2004).

Figure 6.2 Resource abundance and genuine savings between 1970 and 2001

hugely unsustainable according to the World Bank, but still has vast reserves of oil and natural gas. It turns out that calculating natural capital depreciation according to a different method produces a more plausible outcome (see below).

THE POSITIVE CONTRIBUTION OF GENUINE SAVINGS

As we have pointed out, one of the strongest aspects of GS, at least from the perspective of influencing policy, is the fact that it acts as a counterweight to traditional systems of national accounting. Although GNP and GDP do not (and indeed were never intended to) measure welfare, in practice they tend to be construed in exactly that way and thus GS is a related but much more holistic indicator. For example, in 2001 global gross savings amounted to 23.9 per cent of global gross income, whereas global genuine savings were only 12.9 per cent of global gross income. In the Middle East and North Africa, gross savings were 26.9 per cent of gross income, whereas genuine savings were −5.9 per cent of gross income (World Bank, 2003), indicating unsustainability. Furthermore, although we have reservations about the very low GS estimates in certain resource-rich countries, the basic empirical outcome is a valid one for policy: certain resource-rich countries need to invest more of the proceeds of natural capital into the formation of other forms of capital than they currently do.

Beyond this, we can praise the significant research effort that the GS agenda has generated on two fronts. The first concerns the emerging data set that is being amassed. The World Bank has compiled an impressive database on resource extraction and this is subject to regular updates (see Kunte et al., 1998 and World Bank, 1997). In most cases, the data are taken from external sources, but the effort involved in this is not to be underestimated and in any case they still have to be converted into a form apt to adjust gross savings. Progress is also being made on the estimation of environmental pollution damage. Until recently, this component of GS was confined to carbon dioxide emissions, but the Bank has begun to include particulate emissions too. These are quantified based on its own estimates of marginal willingness-to-pay to avoid mortality caused by airborne particulates (equivalent to the shadow price of the stock of particulate emissions: Pandey et al., 2003). Hopefully we will see more pollutants included in the near future. For example, tropospheric ozone pollution would be a valuable addition, as would organic pollution of waterways.

The second impressive outcome of the GS research effort is the theoretical development of the topic, which has advanced knowledge not only about GS, but also about weak sustainability in general. Of course, it might seem rather odd to praise the development of a research area, something that is after all an inherent property of all research. But research on GS has meaningfully advanced since its initial development in the early 1990s. We are now better placed to understand, for example, the implications of different methods for calculating natural resource rents, and our understanding of the significance of per capita estimates of GS versus aggregate GS is also improving. Both of these issues are discussed below. We have also chosen not to mention the theoretical development of the Hartwick rule, and the implications of the optimal growth model. Important contributions include Asheim et al. (2003). Taking on board these improvements leads to a more sophisticated indicator than that initially advanced.

CRITICISMS OF GENUINE SAVINGS

GS has come in for a series of criticisms since its inception, much as its competitors have. These have been discussed in the past by Neumayer (1999, 2003). We will now outline a series of the most significant problems. We do not, however, discuss the general advantages and disadvantages of green national accounting and other indicators of weak sustainability in comparison with indicators of strong sustainability (which assumes at least some natural capital is non-substitutable). The interested reader is directed to Part IV in this volume. It is nevertheless important to remember that the merit of GS as a policy-guiding indicator depends to a great extent on the wider paradigms to which it belongs.

GS is Based on a Model of an Inter-Temporally Efficient Economy

We have already explained that, because GS is a point measure of total wealth in the economy, it can only be a one-sided indicator of sustainability. The problem is then that an economy with positive GS is not necessarily sustainable. This is compounded by the violation of a basic assumption behind the model of GS: the economy develops along an optimal path over all time. In this inter-temporally efficient economy, there is 'a complete set of property rights (that is, no externalities) with competitive households and firms and a full set of forward markets where perfectly rational agents have perfect information and households take full account of the welfare of their actual or prospective descendants' (Neumayer, 1999, p. 155). None of these conditions will hold in reality. Markets fail, especially markets for natural assets, which often do not exist. Hence it is entirely possible that positive GS is associated with, among other things, non-optimal natural resource prices, such that these assets are in fact being extracted unsustainably. This is of course hardly a revelation for environmental and resource economists, whose discipline is founded in large part on the notion that natural resources are under-priced in the economy (see, for example, Pearce and Turner, 1989).

In the present context at least, knowing that the economy is inter-temporally inefficient might suggest a preference for those indicators of (strong) sustainability that set some exogenously defined environmental standard and then measure the opportunity cost of attaining that standard. This so-called hybrid technique for measuring sustainable development was pioneered by Roefie Hueting (1992) and advanced, using dynamic general equilibrium modelling, by Brouwer et al. (1996), Brouwer and O'Connor (1997a, 1997b) and O'Connor and Ryan (1999).[4]

Exogenous Shocks to the GS Model

Quite apart from the unrealistic assumption of intertemporal efficiency, the GS model is vulnerable to shocks from outside the system. The difficulty with exogenous shocks is that the prices existing at the outset will no longer be optimal and will not adequately reflect economic scarcities (Neumayer, 1999). Looking forward from the base year into the future, there is once again no guarantee that GS is giving the correct signals vis-à-vis sustainability. What should therefore happen after such a shock is that prices should be re-estimated. Understandably, Hamilton (1995) rejects this approach as impracticable, and instead proposes that the assumption of efficient pricing is simply dropped. The paradox one ends up in, however, is that the whole method of accounting remains on some level dependent on efficient pricing. Three particular types of exogenous shock are:

1. exogenous technological progress;
2. terms-of-trade effects;
3. a non-constant discount rate.

Exogenous technological progress

The GS model assumes stationary technology. This does not mean that there is no technological progress at all. In fact, as long as progress is embodied in one or other form of capital (in other words is endogenous to the GS model) its effect is accounted for in GS estimates. Instead, it is that fraction of future technological progress that is exogenous, that requires the re-estimation of GS. Equally, exogenous technological progress will only be of interest provided it is non-constant: otherwise it is simply the level of utility (gNNP) that is altered and not the rate of change with time (GS). Presuming technological change does alter the rate of change of utility with time, GS can still be negative even with expanded welfare possibilities, which means that society is losing its capacity to attain that higher level of well being. Alternatively, if exogenous technological progress is contributing less over time to welfare relative to the base year, then even zero GS is insufficient for ensuring sustainability and positive GS is necessary (Neumayer, 1999). In principle, it is possible to treat technological change as an externality and quantify it, but it is very difficult even to approximate unanticipated future change.

Terms-of-trade effects

The effects of changes in future terms of trade are obviously quite different for importing and exporting countries, and are intuitive. If resource rents rise, then the resource exporting country will be better off and the resource importing country worse off than initially predicted. Hence it is theoretically possible at least that the exporting country is not unsustainable, even though its GS rate is negative. Exactly the opposite is true if resource rents unexpectedly fall, due, for instance, to breakthroughs in the development of a substitute so-called backstop technology (for example, solar energy in the case of oil).

A non-constant discount rate

Where the discount rate is non-constant, the meaning of GS estimates becomes similarly ambiguous. In particular, Asheim et al. (2003) show that negative GS at any moment in time need not imply an economy is unsustainable.

The Assumption of Constant Population

The basic model of GS, and our discussion thus far, has focussed on total wealth, and population has been assumed constant. Dasgupta (2001b) points out that this is a reasonable assumption over the very long run, but over the shorter run and especially in the developing world it is less tenable. Thus attention has recently been cast on the question of measuring GS on a per capita basis. The reason for this is rather obvious: one can envisage a situation in which GS is positive, but if population is growing at an even faster rate, then per capita wealth will actually be decreasing. On the face of it, the adjustment to GS that is required is conceptually straightforward (Hamilton, 2003, p. 426):

$$\frac{d}{dt}\left(\frac{W}{P}\right) = \frac{\frac{dW}{dt}}{P} - \frac{\frac{dP}{dt}}{P}\frac{W}{P}, \tag{6.5}$$

where W = total wealth, P = population and dW/dt = GS. Thus the per capita measure of GS is equal to the net change in total wealth per capita minus the product of total wealth per capita and the population growth rate.

Hamilton (2003) makes preliminary empirical estimates of GS per capita for 110 developed and developing countries. But first he conducts a sensitivity analysis of the results of GS per capita according to different population growth rates for the USA in 1997. He concludes that GS per capita is responsive to population growth, and an increase in p from 0.8 per cent p.a. to 1.0 per cent p.a., *ceteris paribus*, is sufficient to push GS per capita below zero. On a country-by-country basis, the pattern of per capita estimates reflect the World Bank's aggregate estimates: it is the resource-rich countries of Sub-Saharan Africa, the Middle East and Northern Africa that tend to have the most negative GS per capita. Clearly, having negative GS on aggregate automatically translates into negative GS per capita (unless population growth is negative). But crucially some countries with positive GS on aggregate have negative GS per capita: for example, Jordan and Niger, for whom of course population growth rates are high. This emphasises the value in computing GS per capita alongside GS on aggregate.

Yet the problem of accounting for population growth may not be as simple. Dasgupta (2001b) and Arrow et al. (2003) derive a fundamentally different formula for GS per capita, based on the inclusion of the stock of population in the social welfare (utility) function as a capital asset. As Asheim (2004) puts it, following this reasoning makes instantaneous well being (which is what point estimates of GS measure) dependent on population size. This is the position of 'total utilitarianism'. A simplified version of Arrow et al.'s (2003) GS per capita is therefore:

$$\text{GS} = \frac{\text{net investment in capital (various forms)} + \text{population growth}}{\text{population size}} \tag{6.6}$$

One might immediately object to the idea that a larger future population should be given greater welfare weight because of just that. Arrow et al. (2003) argue that this weighting is in keeping with the simple principle of treating people equally (discounting notwithstanding), and Dasgupta (2001b) also showed that the alternative position of 'average utilitarianism' has its own implications that may not be ethically defensible.[5] It is in any case not necessarily true that a larger future population receives more weight, *ceteris paribus*, because population growth is valued in the GS function at its shadow price, and this could be negative. The only restriction on the shadow price of population growth according to their derivation is that it may not equal zero.

If the above formula is applied, then an important question is what rate of population growth to choose. A common assumption in models with a growing population is that population growth is constant: that is, population grows exponentially. In this case, Arrow et al. (2003) show that the GS formula simply collapses to per capita GS as in Hamilton (2003). But this is also an untenable assumption, because population growth is slowing worldwide. A more reasonable growth function to impute is logistic growth, where population initially grows exponentially, but later converges to a constant level. In this case, if one decides to retain population in the social welfare function, then the modified Arrow et al. method is the correct one. This is an emerging research agenda, and important contributions are expected to follow in the next few years. In the meantime, we conclude that the relatively straightforward adjustment made in equation (6.5) is worthwhile.

Calculating Natural Capital Depreciation

The World Bank's method for calculating resource rents based on price minus average cost is problematic. This much was suggested by its empirical results, some of which appeared superficially odd. As we have mentioned, GS rates seem to be remarkably low in certain resource-rich countries. Neumayer (2000) in particular asked if GS in North Africa and the Middle East truly was as low as −30 per cent of gross income at the end of the 1970s, and if GS in Saudi Arabia, a nation with reserves of oil and natural gas that are still enormous even now, was plausibly lower than −20 per cent of gross income over most of the Bank's 25-year measurement period? If these results were true, then the regions and countries in question would consume the better part of their total capital stock within a matter of decades, leading to economic collapse. Needless to say, we see no signs of this happening.

In an inter-temporally efficient economy, calculating the depreciation of natural capital is theoretically straightforward, being equal to the so-called total Hotelling rent (Hotelling, 1931; Hartwick, 1990; Hamilton, 1994; Neumayer, 1999, 2003):

$$(P - MC)^{*}R \tag{6.7}$$

where MC is marginal cost. But data on marginal costs are very difficult to obtain in reality, so the Bank falls back on average costs as in equation (6.4). In fact, the Bank's method is just one of several. Of these, El Serafy (1981, 1989 and 1991) estimated natural capital depreciation according to the following formula:

$$(P - AC)^{*}R^{*}\left[\frac{1}{(1+r)^{n+1}}\right], \tag{6.8}$$

where r = the discount rate and n = the number of remaining years of the resource stock.

The tendency is for n to be set equal to the static reserves to production ratio, which is the number of years the reserve stock would last if production were maintained equivalent to the base year. Comparing (6.4) and (6.8), we can clearly see that if both r and n are large, then the 'El Serafy' method will produce a smaller estimate of natural capital depreciation, and it follows that GS rates will be more positive, *ceteris paribus*. The 'El Serafy' method in effect partitions the rents from resource extraction into the 'user cost' of resource extraction – that is, the share of resource receipts that should properly be considered as capital depreciation – and 'sustainable income' (in a Hicksian sense), which is a level of consumption that can be sustained indefinitely.[6]

The rather important difference between the 'El Serafy' method and the Bank's method is that the former does not depend on the assumption of inter-temporal efficiency and hence optimal prices. Since there is no reason to presume resource pricing is efficient (see above), it is more defensible to employ a method that does not depend on it.[7] Furthermore, the Bank's method is in any case at best an approximation of the theoretically correct method, because it substitutes average costs for marginal costs. To the extent that marginal costs are increasing (it becomes increasingly costly to extract successive units of a resource), then the application of average costs should overestimate the depreciation of natural capital. The 'El Serafy' method, on the other hand, uses average costs without apology, because it does not depend on marginal costs.

In response to questioning the realism of GS estimates for certain regions and nations, Neumayer (2000) re-estimated GS using the 'El Serafy' method. Applying a discount rate (*r*) of 4 per cent p.a., the regions of Sub-Saharan Africa, North Africa and the Middle East no longer had negative GS, and most individual countries also passed from negative GS into positive GS, particularly those with large remaining reserves relative to production. Other countries that continued to record negative GS had negative savings irrespective of natural capital depreciation, while only a handful of countries could still be said to be weakly unsustainable due in itself to unsustainable natural resource extraction. Auty and Mikesell (1998) provided similar results in the case of Indonesia.

All this seems to suggest that the 'El Serafy' method is superior to the Bank's method, but this may not be true in all cases. The method is very sensitive both to *r* and *n*, and there are problems associated with arriving at both values (Auty and Mikesell, 1998). What is the correct discount rate is always an open question, and taking a high value of, say, 10 per cent p.a. leads 'El Serafy' GS estimates to deviate even more from the Bank's estimates (Neumayer, 2000). It is equally unclear what values *n* should take, since it requires predictions into the future and is thus troubled by uncertainty. We explained above that *n* is generally estimated as the static reserves to production ratio, but reserves data are much less reliable in general than production data. Broadly, if *r* and *n* are *both* small, then the Bank's and the 'El Serafy' method converge somewhat, and the adjustment may not be meaningful. This will be true of *r* if it is of the order of 4 per cent p.a. or lower, and of *n* if it is around 20 years or lower. Scanning data from the US Bureau of Mines (various years) tends to reveal that *n* lies between 20 and 30 in the case of many resources for many countries, so the Bank's method will not normally be far off the mark. Vis-à-vis Saudi Arabia and other countries with very large remaining reserves relative to production, the results generated by applying the Bank's method are nonsensical, but otherwise the Bank's method can still be usefully regarded as imposing a conservative sustainability standard.

Accounting for Environmental Pollution

The World Bank estimates the depreciation of natural capital due to environmental pollution as the total damage cost of national carbon dioxide emissions. Fine particulate emissions were added in 2003, though the retrospective estimates of GS from 1970 to the present day that we use do not include these. This is quite clearly a restrictive approach, and the Bank knowingly omits many other types of pollutant (including air pollutants such as sulphur dioxide and oxides of nitrogen, water pollutants such as faecal coliforms, and ground contaminants such as heavy metals). The upshot of this may well be, among other things, that developed countries are not as sustainable as one might presume. Hamilton and Atkinson's (1996) results suggest this is the case: they estimated the damage cost of air pollution in the UK to be between 3 per cent and 5 per cent of GDP during the 1980s, enough to push the UK's GS below zero for most of the early 1980s.

The Bank sees its hands tied in this respect: there simply are not enough data available to estimate a comprehensive set of damage costs. It would be fair to say that, in general, of all the components of GS the damage costs of environmental pollution are the most incomplete and 'approximate'. There is even some debate as to how the value of environmental pollution should be calculated in the first place. Hamilton and Atkinson (1996) and the World Bank apply the damage cost approach, where emissions of the relevant pollutant (net of natural dissipation) are multiplied by their shadow price. Other studies have focussed on so-called maintenance costs, which reflect the cost of returning the environment to some previous state based on marginal abatement costs (e.g. Prince and Gordon, 1994). In an optimal economy, the two methods should amount to the same, but we know this is not the case and it is hence likely that maintenance costs, based on marginal pollution abatement costs, will understate the costs of pollution (Prince and Gordon estimate the cost of air *and* water pollution in the USA in the early 1980s to be only 1 per cent of GDP: this is considerably lower than the Hamilton and Atkinson estimate). But damage costs are not beyond censure themselves. Most are estimated in a partial equilibrium context as part of a cost–benefit analysis (CBA), but what is required for estimates to be compatible with systems of national accounting is a general equilibrium estimate. More research and practice is required here too, but for the moment we can conclude that GS estimates, particularly in developed countries, may be too high, *ceteris paribus*.

In the context of costing environmental pollution, there is also the controversial issue of transboundary and global pollution and how it is integrated into green national accounting. This particularly affects carbon dioxide emissions. Either one simply estimates the damage cost of pollution wherever it occurs, and hence certain countries will pay the welfare price for others' emissions, or the damage cost of pollution is attributed to the emitting country. The latter is a basic application of the 'polluter pays principle' that now wields considerable influence in international environmental policy-making. On the other hand, the damage cost of emissions is not strictly speaking equivalent to the environmental capital stock that determines the impact of climate change on a country's economy. Instead, it is the global concentration of carbon dioxide in the atmosphere, a function of global emissions, which does so (Ferreira and Vincent, 2003). Clearly this decision will exert a considerable influence on GS rates.

In fact, it has a corollary in the case of accounting for resource extraction, insofar as some have argued that the resources depleted in developing countries of the South for the purpose of consumption or capital accumulation in developed countries of the North should properly be debited from the national accounts of the developed country. Again this adjustment significantly changes the distribution of GS rates, being more positive for resource exporters and more negative for importers (Proops et al., 1999). In this latter case, however, there is no real argument for adjustment. The purpose of estimating GS is to find out the magnitude of a nation's natural capital depreciation as a share of total national capital formation. Negative GS rates, *especially* if caused by excessive exports to developed countries of the North, should indicate that developing countries of the South need to invest more of the proceeds of natural capital into the formation of other forms of capital than they currently do. And the results should also affect policy-making in the North. Developed countries should assist developing countries experiencing negative GS rates in attempting to become sustainable.

There is no real case for following the same logic in respect of environmental pollution, however. Strictly from the perspective of whom the natural capital (sink resource) belongs to, deductions should be made from the recipient country's GS. But this is hardly the policy signal one wants to give in this context. Instead, it seems difficult in principle to reject the notion that the polluter should 'pay', which is in accordance with the way the Bank values pollution. Also from a practical perspective, it is easier and safer to calculate damage cost estimates based on national emissions rather than ambient emissions concentrations.

CONCLUSIONS ON THE POLICY USEFULNESS OF GENUINE SAVINGS

Whether one believes in the policy-guiding value of GS depends at the outset on whether one subscribes to the weak sustainability paradigm.

Admittedly there have been moves towards dealing with the non-substitutability of natural capital within the GS framework. Atkinson et al. (2003) propose that, as the asset base of some natural resource is depleted up to its critical level, the shadow price of the asset should approach infinity. In practical terms, the magnitude of the term for natural capital depreciation becomes very large indeed. But there are at present limits to this approach. The loss of critical natural capital still needs to be measured through marginal WTP, and this is difficult enough for incremental as opposed to very large losses of welfare. In essence, we are not currently equipped to measure the welfare value of losses of critical natural capital. In that case, if one is concerned with strong sustainability, then GS results are largely uninteresting.

Within the confines of the weak sustainability paradigm, we have praised GS as a meaningful counterweight to gross product in the measurement of social welfare (understanding, of course, that gross product was never intended to be a measure of social welfare), and as an indicator with a direct (if one-sided) sustainability criterion. On the other hand, the thrust of our discussion is that GS is a very rough measure of sustainability. The assumption of an inter-temporally efficient economy is undoubtedly problematic, and thus even non-negative GS rates cannot really rule out unsustainable development. In much the same way, the validity of point estimates of GS depends on the absence of external shocks to the system. If there are any, then all prices, and in turn GS, would have to be re-estimated. These are fundamental problems for GS and we recommend all estimates be accordingly interpreted with a great deal of caution. If one seriously objects to the optimality assumption, then it may be preferable to set exogenous environmental standards and model the opportunity cost of reaching them as the so-called hybrid indicators do. In this context, modelling opportunity costs in a dynamic general equilibrium framework (e.g. O'Connor and Ryan, 1999) is the most appropriate method. However, although there is insufficient scope here, it should be noted that the problems apparent in the hybrid approach are no less grave (see Neumayer, 1999, 2003).

The measurement of natural capital depreciation is another problem for GS. We have shown that GS estimates are sensitive to the method of calculating rents from resource extraction. The World Bank's estimates, by their own admission, are at the high end, and probably overestimate the unsustainability of certain resource-dependent regions and countries. Even patchier is the estimation of the value of environmental pollution damage. At present, the World Bank judges there to be so few data that it can only estimate the values of carbon dioxide and particulate pollution damage. Even in these cases, the estimates of marginal pollution costs are very rough. In fact, this patchy data coverage is also an issue for extractive resources. It is striking that the least sustainable regions and countries according to the World Bank are those heavily dependent on fossil fuels and minerals.

To summarise, the most useful policy suggestion to emerge from GS studies is that certain resource-dependent countries need to invest more of the proceeds of natural capital into the formation of other forms of capital than they currently do. On the other hand, the debate over calculating resource rents means that countries with still large remaining reserves of fossil fuels – mainly Saudi Arabia and some other Gulf States – are almost certainly more sustainable than the World Bank suggests. Other countries, however, that are heavily dependent on resources not included in the analysis such as fish or soil (via agriculture) may well be less sustainable. One can, for example, ask if Sub-Saharan Africa would be even less weakly sustainable after calculating the depletion of soils? In any case, the fact that its main results become reversed for some countries if another, and not inferior, method for calculating natural capital depreciation is used, sheds great doubt on the validity and reliability and therefore on the policy usefulness of the measure.

For developed countries, GS produces the result that everywhere weak unsustainability is avoided. This may or may not be true. These countries are not especially resource-dependent, and do tend to invest significantly in capital formation, but including a more comprehensive range of environmental pollutants would undoubtedly drive GS downwards. Hence the really interesting policy outcome that this conclusion currently evades is that some developed countries might be unsustainable on the grounds of excessive pollution.

At the present time then, GS provides some interesting if *generic* policy guidance to sustainability planners. Given improved coverage and estimation of natural resource depletion in the future, we may obtain more interesting and accurate results. Given the restrictive assumptions of the method, however, and the fact that few if any environmental data can ever be considered truly accurate, it would be a mistake to interpret GS rates too literally.

NOTES

1. Dasgupta (2001a, 2001b) and Neumayer (1999, 2003) share the view that genuine *investment* would be a better term to use than genuine savings, because in macroeconomics savings tends to be defined as private savings. As GS applies it, savings means the sum of private plus public savings (the latter being taxes minus public expenditures), hence genuine savings equals genuine investment.
2. Hartwick (1977) showed that a resource-dependent economy could maintain its consumption level over time if it invested all the rents from resource extraction in produced capital.

3. This is presumably at least in part due to Kirk Hamilton's affiliation with the World Bank's Environment Department.
4. Most hybrid indicators have been developed to measure strong sustainability, insofar as environmental standards are set in order to protect what equates to critical natural capital. However, the method is inherently flexible and the opportunity costs of attaining a range of environmental standards, differing in their stringency, can be modelled simultaneously.
5. In a simple timeless economy with two populations, keeping population out of the social welfare function allows a result where the government distributes less to each member of the larger population (Dasgupta, 2001b, pp. 99–100).
6. See Neumayer (2000) for a formal derivation.
7. The Bank is in any case inconsistent in its assumption of optimal prices, since it presumably rejects optimality when deciding to ignore terms-of-trade effects.

REFERENCES

Arrow, K.J., P. Dasgupta and K.-G. Mäles (2003), 'The genuine savings criterion and the value of population', *Economic Theory*, **21**, 217–25.

Asheim, G. (1994), 'Net national product as an indicator of sustainability', *Scandinavian Journal of Economics*, **96**, 257–65.

Asheim, G. (2004), 'Green national accounting with a changing population', *Economic Theory*, **23**, 601–19.

Asheim, G., W. Buchholz and Co Withagen (2003), 'The Hartwick rule: myths and facts', *Environmental and Resource Economics*, **25,** 129–50.

Atkinson, G., K. Hamilton and W. Nalvarte (2003), *Sustainability, Green National Accounting and Deforestation*, London: Department of Geography and Environment, London School of Economics and Political Science, mimeo.

Auty, R.M. and R.F. Mikesell (1998), *Sustainable Development in Mineral Economies*, Oxford: Clarendon.

Brouwer, R., M. O'Connor and W. Radermacher (1996), *Defining Cost-effective Responses to Environmental Deterioration in a Periodic Accounting System*, proceedings of the third meeting of the London Group on Natural Resource and Environmental Accounting, Stockholm, 28–31 May 1996, Stockholm: Statistics Sweden.

Brouwer, R. and M. O'Connor (1997a), *Final Summary Report of Research Project No. EV5V-CT94-0363, Methodological Problems in the Calculation of Environmentally Adjusted National Income Figures*, C3ED.

Brouwer, R. and M. O'Connor (1997b), *Project Final Report of Research Project No. EV5V-CT94-0363, Methodological Problems in the Calculation of Environmentally Adjusted National Income Figures*, C3ED.

Dasgupta, P. (2001a), 'Valuing objects and evaluating policies in imperfect economies', *Economic Journal*, **111**, C1–C29.

Dasgupta, P. (2001b), *Human Well-Being and the Natural Environment*, Oxford: Oxford University Press.

El Serafy, S. (1981), 'Absorptive capacity, the demand for revenue, and the supply of petroleum', *Journal of Energy and Development*, **7**, 73–88.

El Serafy, S. (1989), 'The proper calculation of income from depletable natural resources', in Y.J. Ahmed, S. El Serafy and E. Lutz (eds), *Environmental Accounting for Sustainable Development: a UNDP-World Bank Symposium*, Washington, DC: World Bank, pp. 10–18.

El Serafy, S. (1991), 'The environment as capital', in R. Costanza (ed.), *Ecological Economics: the Science and Management of Sustainability*, New York: Columbia University Press, pp. 168–75.

Fankhauser, S. (1995), *Valuing Climate Change: the Economics of the Greenhouse*, London: Earthscan Publications.

Ferreira, S. and J.R. Vincent (2003), *Why Genuine Savings?*, San Diego: Department of Economics, University of California, mimeo.

Hamilton, K. (1994), 'Green adjustments to GDP', *Resources Policy*, **20**, 155–68.

Hamilton, K. (1995), *Sustainable Development and Green National Accounts*, London: University College London, unpublished PhD thesis.

Hamilton, K. (2003), 'Sustaining economic welfare: estimating changes in total and per capita wealth', *Environment, Development and Sustainability*, **5**, 419–36.

Hamilton, K. and G. Atkinson (1996), 'Air pollution and green accounts', *Energy Policy*, **24**, 675–84.

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

Hartwick, J.M. (1977), 'Intergenerational equity and the investing of rents of exhaustible resources', *American Economic Review*, **67** (5), 972–74.

Hartwick, J.M. (1990), 'Sustainability and constant consumption paths in open economies with exhaustible resources', *Review of International Economics*, **3**, 275–83.

Hotelling, H. (1931), 'The economics of exhaustible resources', *Journal of Political Economy*, **39** (2), 137–75.

Hueting, R. (1992), 'Correcting National Income for Environmental Losses: a Practical Solution for a Theoretical Dilemma', in J.J. Krabbe and W.J.M. Heijman (eds), *National Income and Nature: Externalities, Growth and Steady State*, Dordrecht and Boston, MA: Kluwer, pp. 23–47.

Kunte, A., K. Hamilton, J. Dixon and M.Clemens (1998), *Estimating National Wealth: Methodology and Results*, Washington, DC: World Bank.

Neumayer, E. (1999), *Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms*, Cheltenham, UK, Northampton, MA, and USA: Edward Elgar.

Neumayer, E. (2000), 'Resource accounting in measures of unsustainability: challenging the World Bank's conclusions', *Environmental and Resource Economics*, **15**, 257–78.

Neumayer, E. (2003), *Weak versus Strong Sustainability: Exploring the Limits of Two Opposing Paradigms*, second revised edition, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.

O'Connor, M. and G. Ryan (1999), 'Macroeconomic cost-effectiveness and the use of multi-sectoral dynamic modelling as an environmental valuation tool', *International Journal of Sustainable Development*, **2**, 127–63.

Pandey, K.D., K. Bolt, U. Deichmann, K. Hamilton, B. Ostro and D. Wheeler (2003), *The Human Cost of Air Pollution: New Estimates for Developing Countries*, Washington, DC: Development Research Group and Environment Department, World Bank.

Pearce, D. and G. Atkinson (1993), 'Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability', *Ecological Economics*, **8** (2), 103–8.

Pearce, D.W. and R.K. Turner (1989), *Economics of Natural Resources and the Environment*, Hemel Hempstead: Harvester Wheatsheaf.

Pezzey, J. (2003), *One-sided Unsustainability Tests with Amenities and Shifts in Technology, Trade and Population*, Canberra: CRES, Australian National University.

Pezzey, J. and C. Withagen (1995), 'The rise, fall and sustainability of capital-resource economies', *Scandinavian Journal of Economics*, **100**, 513–27.

Prince, R. and P.L. Gordon (1994), *Greening the National Accounts*, Washington, DC: Congressional Budget Office.

Proops, J., G. Atkinson, B. Frhr. v. Schlotheim and S. Simon (1999), 'International trade and the sustainability footprint: a practical criterion for its assessment', *Ecological Economics*, **28**, 75–97.

Solow, R.M. (1974), 'Intergenerational equity and exhaustible resources', *Review of Economic Studies*, Symposium, 29–46.

US Bureau of Mines (various), *Mineral Commodity Summaries*, Washington, DC: Department of the Interior.

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

World Bank (2003), *World Development Indicators*, Washington, DC: World Bank.

World Bank (2004), Adjusted Net Savings Data, Washington, DC: World Bank (http://lnweb18.worldbank.org/ESSD/essdext.nsf/44ByDocName/GreenAccoutingWealthEstimates).