Genuine savings: a critical analysis of its policy-guiding value

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Abstract: Genuine savings (GS) is an established measure of weak sustainability (WS). It can be shown, with the help of a dynamic optimisation model, that an economy with persistently negative GS cannot be regarded as weakly sustainable. The main conclusion drawn from the empirical estimates of GS presented in this paper is that many resource intensive, developing economies appear to be weakly unsustainable, whereas developed countries are not. The paper praises the GS concept in terms of the positive contribution it has made to the measurement of WS and to the concept of sustainable development more generally. It then analyses, in some depth, the various criticisms of GS. These include the unrealistic assumption of an inter-temporally efficient economy, the dubious treatment of exogenous shocks and population growth, the inappropriate method for computing natural capital depreciation resulting from resource extraction, and the inadequate accounting for environmental pollution. We conclude that, despite various substantial problems, GS represents the best attempt at measuring WS so far with considerable scope for future development and improvement.

Keywords: weak sustainability; strong sustainability; national accounting; capital depreciation; resource extraction; environmental pollution; genuine savings.

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1 Introduction

The concept and policy goal of sustainable development is now very widely accepted. An essential element of sustainable development planning and policy is the ability to measure sustainability. A considerable number of competing indicators of sustainable development have emerged over the last fifteen years or so – a direct result of the contested definition and the theory of the concept itself [1–3]. A crude but powerful means of discriminating between the various indicators of sustainable development is to categorise them in terms of so-called measures of 'weak sustainability' (WS) and 'strong sustainability' (SS). The two are generally distinguished by the extent to which they assume natural and produced assets are substitutable. WS typically assumes infinite substitutability, while SS is based on the belief that natural capital is either entirely non-substitutable, or that a portion of it – the so-called *critical* natural capital – cannot be replicated by man-made capital.

Within the WS tradition, research efforts involving 'green' adjustments to conventional systems of national accounting are well established [4]. This literature traces its roots back to the work of such neoclassical economists as Robert Solow [5] and John Hartwick [6]. Both were concerned with modelling a development path in which social welfare or well being is non-declining. One variation of these 'green' adjustments to national accounting is genuine savings (hereafter GS) [7–9]. The term 'genuine' was coined by Hamilton [10] to reflect the fact that GS includes all forms of utility-generating capital – such as natural capital, which gives GS its 'green' properties; human capital; and, in principle at least, social capital [11]. The main objective of this paper is to critically discuss the policy-guiding value of GS with attention devoted to both its strengths and weaknesses.

As a sustainability indicator, GS can be derived from a dynamic optimisation model, such as that developed by Hartwick [12]. Given a range of simplifying assumptions that will be critically discussed in Section 4, the economic planner's problem is to maximise the present value of social welfare over all time. Solving this maximisation problem produces a measure of green net national product (gNNP), which is equal to society's consumption plus the sum of net changes in all the capital stocks valued at their shadow prices. The relevant shadow prices are the prices that would exist in an inter-temporally efficient economy devoid of externalities (this is one such assumption). GS constitutes the net changes in all the capital stocks valued at their shadow prices. Circumnavigating the rather complex construction and derivation of GS [1, pp.149–152], it is measured in terms of the following equation:

GS = net investment in produced capital – net depreciation of natural capital + investment in human capital (1)

Keeping GS above zero can be interpreted as a modification to the so-called Hartwick rule on sustainability. In his seminal contribution, Hartwick [6] showed that a resource-dependent economy could maintain its consumption level over time if it invested all the rents from resource extraction in man-made capital. If GS is below zero at some point in time, the economy is not weakly sustainable [13,14]. Crucially, keeping GS above or equal to zero proves to be a necessary but *insufficient* condition for ensuring sustainability under the WS paradigm (i.e., natural capital is infinitely substitutable according to the above formulation). The insufficiency condition arises because adherence to the Hartwick rule and a non-negative value of GS only guarantees WS if the rule is adhered to from the beginning of time up to infinity [15,16]. If, however, the economy has had negative GS in the past, a positive GS at some later point in time is insufficient to guarantee sustainability. This is the likely case with most sustainability planning. We will reprise this issue in Section 4. Suffice to say, this means that GS is, at best, a one-sided sustainability indicator.

The remainder of this paper is structured as follows. Section 2 presents empirical estimates of GS. Section 3 discusses the positive contributions that GS has made to the measurement of sustainability. Section 4 analyses various criticisms that can be, and have been, raised against GS. Section 5 concludes with a discussion of the policy usefulness of GS.

2 Empirical estimates of genuine savings

Many consider Repetto et al. [17] pioneering study for Indonesia to be the first noteworthy example of green national accounting in practice. Since then a significant number of studies have been undertaken for single countries and selected groups of countries (see [18] for Costa Rica; [19] for Mexico; and [20] for several countries). However, not all such studies have measured GS per se, but have instead concentrated on estimating gNNP. In the case of Repetto et al. [17], the results of the study on Indonesia showed that Gross National Product (GNP) grew at 7.1% per annum (p.a.) between 1971 and 1984, but gNNP only grew at 4.1% p.a. over the same period. A useful conclusion that could be drawn here was that actual growth – i.e. net of depreciation of natural and produced capital – was someway short of that apparently indicated by GNP. Since one of the principal objectives of green national accounting is to act as a counterweight to conventional gross product, the study can be judged to have yielded a useful result, and the direction of the adjustment intuitive. Also, from a theoretical perspective, gNNP measures serve as a valuable extension of the Hicksian concept of national income – i.e. the maximum amount of produced output that a nation can consume at some point in time while maintaining constant wealth.

Although the difference between gNNP and GS is a fine one – for example, consumption is netted out in arriving at the latter – there is a problem with using gNNP as an indicator of sustainability. As Atkinson et al. [21] argued, the direct implications of gNNP for sustainability policy are limited because relatively simple downward shifts in income entailed by greening GNP indicate little in terms of whether a nation is operating in a sustainable manner. Returning to the Repetto et al. study [17], it is difficult to draw any meaningful sustainability conclusion from the still positive growth rate of gNNP of 4.1% p.a. Arguably, what one should be interested in are changes in total wealth, which is exactly what GS indicates. Of course, it must be remembered that maintaining non-negative GS is a direct one-sided indicator of weak (un)sustainability.

An early empirical application of GS was made by Pearce and Atkinson [22] for 18 countries. Since then, the GS mantle has very much been assumed by the World Bank [23] which now regularly publishes a comparatively comprehensive GS measurement exercise for over 150 countries [24].

In simplified form, the World Bank operationalises GS, which it now calls 'Net Adjusted Savings', as follows:

GS = investment in man-made capital – net foreign borrowing + net official transfers – depreciation of man-made capital – net depreciation of natural capital + current education expenditures (2)

Compare this version with the stylised formulation in equation (1). Estimates of gross investment in man-made capital are made with relatively little dispute in contemporary national accounting, while estimates of man-made capital depreciation also exist, albeit they are less common. However, the science of estimating net depreciation of natural capital is much more embryonic. It can be divided at a basic level into resource extraction on the one hand, and environmental pollution on the other. The latter is measured in terms of natural capital depreciation brought about by a declining sink capacity of the natural environment. The World Bank estimates natural capital depreciation arising from resource extraction of 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. Note that there are a great many resources omitted, particularly renewable resources such as water resources, fisheries, soils, etc. Depreciation estimates are computed as the product of price minus average costs of extraction multiplied by the volume of extraction:

$$(P - AC) \times R \tag{3}$$

where P is the resource price, AC is the average cost, and R is the volume of extraction (in the case of a renewable resource R represents harvest beyond natural regeneration). There is a potentially serious drawback with applying this method of estimation, which is discussed in Section 4.

As concerns environmental pollution, in the estimation exercise undertaken by the World Bank in 1997, environmental pollution was taken to be the estimated damage cost of carbon dioxide emissions, where each ton of carbon emitted was valued at US$ 20 per metric tonne of carbon [25]. In the most recent estimation (2003), the World Bank included the damage costs of particulates in the air. Note, again, that this is a very limited estimate of environmental pollution given the many other forms and media it takes. Similarly, net education expenditures are a crude approximation of investment in human capital, although there are few realistic alternatives [26].

The World Bank studies have produced some interesting and, at times, surprising results. Over the calculation period 1976–2000, the OECD countries, together with East and South Asia, have never had negative GS. This is also true for global GS. In practicality, these areas, and the world as a whole, have apparently not been weakly unsustainable over the past 25 years or so (however, remember the one-sided test proviso). Latin America and the Caribbean had negative GS for a time during the early 1980s, but the most problematic areas have been Sub-Saharan Africa, North Africa, and the Middle East. The former region has registered negative GS since the early 1980s, while the latter two regions have always had negative GS. One conclusion we can draw from these data is that the regions with the greatest natural resource extraction are also the poorest performers in terms of GS [2]. This is also true at the national level of analysis. In Sub-Saharan Africa, it must also be said that net savings, irrespective of natural capital depreciation, are often negative too. In other words, the total *man-made* wealth of these countries is also decreasing. The World Bank's estimates of net natural capital depreciation simply worsen the general picture of Sub-Saharan Africa. The surprising element of the World Bank's results is that some heavy resource extractors appear more unsustainable than intuition would suggest [1,2]. Saudi Arabia is the clearest example of this. It is hugely unsustainable according to the World Bank, but still has vast reserves of oil and natural gas [2]. It turns out that calculating natural capital depreciation according to a different method produces a more plausible outcome (see Section 4).

3 The positive contribution of genuine savings

Criticisms of the WS paradigm notwithstanding, one of the strongest aspects of GS, at least from the perspective of influencing policy, is the fact that it serves as a counterweight to conventional 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. GS, however, is a related but much more holistic indicator.

The latest edition of the World Bank's *World Development Indicators* [25] is revealing in the following respect – gross savings is directly compared with net savings (excluding natural capital depreciation) and genuine savings [25, Table 3.15, p.119]. The basic outcome of empirical estimates of GS is also a valid one for policy. That is, certain resource-dependent countries need to invest more of the proceeds of natural capital depletion into the formation of other forms of capital than they currently do.

Beyond this, the significant volume of research effort that the GS agenda has generated can be praised 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 in order to calculate what it calls 'Net Adjusted Savings'. The database is subject to regular updates [27,28]. In most cases, the data are taken from external sources, but the effort involved in undertaking this exercise is not to be underestimated. In any case, the data still have to be converted into a form suitable for adjusting gross savings. Progress is also being made on the estimation of environmental pollution damage. Until the most recent edition of *World Development Indicators*, this component of GS was confined to carbon dioxide emissions. As previously mentioned, the World Bank now includes damage costs of particulate emissions that are based on estimates of the marginal willingness-to-pay to avoid mortality caused by airborne particulates [29]. Hopefully, more pollutants will be included in the World Bank estimates 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 flagged above is the theoretical development of the topic of sustainable development. This has not only forwarded our knowledge about GS, but also that of WS and sustainability per se. Of course, it might seem rather odd to praise the development of a research area, something that is, after all, an inherent property of research in general. But research on

GS since the early 1990s has meaningfully advanced our understanding of the implications of adopting different methods for calculating natural resource rents, as well as our understanding of the significance of per capita estimates of GS vs. aggregate GS. One should also mention the beneficial impact that GS research has had on the theoretical development of the Hartwick rule and its implications for the optimal growth model [30]. These improvements lead to a more sophisticated indicator of sustainability than that initially advanced.

4 Criticisms of genuine savings

Since its inception, the concept of GS has come in for a series of criticisms. These have been discussed in the past by Neumayer [1,2]. We will now outline and discuss the most significant weaknesses. We do not, however, discuss the advantages and disadvantages of WS in comparison with SS, as the scope of this debate exceeds the ambit of the present paper [1,2,31–33]. It is nevertheless important to remember that the merit of GS as a policy-guiding indicator depends to a great extent on its limitation to measuring WS.

4.1 Genuine savings is based on a model of an inter-temporally efficient economy

In Section 1 we explained that, because GS is a point measure of total wealth in the economy, it can only be a one-sided indicator of (un)sustainability. The problem that an economy with a positive GS could be weakly unsustainable is compounded by the violation of a basic assumption behind the GS model. It is assumed that 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." [1, p.155]

None of these conditions will hold in reality. Markets fail, especially inter-temporally, and natural assets exhibit public goods characteristics. Hence, it is entirely possible that positive GS is associated with, among other things, non-optimal natural resource prices, which result in resource assets 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 a market economy [34].

In the present context, at least, knowing that the economy is inter-temporally inefficient might suggest a preference for SS indicators that involve the identification of some exogenously defined environmental standard and an estimate of the cost of attaining that standard. Indeed, Roefie Hueting [35], who pioneered this so-called 'hybrid' approach, explicitly recognises that the research agenda is a response to the insurmountable problems the practitioner confronts in constructing a theoretically sound indicator. Three of the most important hybrid indicators are Sustainability Gaps [36,37]; the Greened National Statistical and Modelling Procedures (GREENSTAMP) [33]; and Sustainable National Income according to Hueting [35]. Hybrid approaches are generally regarded as indicators of strong sustainability insofar as the standards set are relatively stringent [2] but, in principle, this need not be the case.

4.2 Exogenous shocks to the GS model

Quite apart from the unrealistic assumption of inter-temporal 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. Moreover, they will not adequately reflect economic scarcities [1]. Looking forward from the base year into the future, there is once again no guarantee GS is giving the correct signals on WS. To correct the impact of exogenous shocks, it is necessary to re-estimate prices. Understandably, Hamilton [38] rejects this approach as an impracticable one. He instead proposes that the assumption of efficient pricing be simply dropped. The paradox one ends up in, however, is that the whole method of accounting remains dependent on efficient pricing. Three possible types of exogenous shock that could be experienced are:

- exogenous technological progress
- terms-of-trade effects
- a non-constant discount rate.

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 – i.e. 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 necessitates a re-estimation of GS. This is possible in principle by treating technological progress as an externality and then attempting to quantify it. The adjustments can be very large or rather small [39]. In any case, it is very difficult to approximate future unanticipated change, and exogenous technological progress will only be of interest provided it is non-constant; otherwise it is simply the level of utility that is altered and not the rate of change with time – i.e., gNNP rather than GS. With this in mind, GS can still be negative even with expanded welfare possibilities, which means the capacity of a nation to attain the higher level of well being is undermined. Alternatively, if exogenous technological progress contributes less over time to welfare relative to the base year, then even zero GS is insufficient for ensuring sustainability. In this instance, positive GS is necessary to achieve sustainability [1].

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 (see below), then the resource exporter will be better off and the resource importer worse off than initially predicted. Hence, it is theoretically possible that the exporter is not weakly unsustainable, even though its GS is negative. Exactly the opposite is true if resource rents unexpectedly fall due, for instance, to breakthroughs in the development of a substitute or so-called backstop technology (for example, solar energy in the case of oil).

Where the discount rate is non-constant, the meaning of GS estimates becomes similarly ambiguous. In particular, Asheim, Buchholz and Withagen [30] show that negative GS at any moment in time need not imply an economy is weakly unsustainable.

4.3 The assumption of constant population

The basic model of GS, and our discussion thus far, has focussed on total wealth. The population has been assumed to be constant. Dasgupta [8] 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 the population is growing at a faster rate, per capita wealth will actually be decreasing. On the face of it, the adjustment to GS required is conceptually straightforward [40, p.426]:

$$\frac{d}{dt}\left(\frac{W}{P}\right)=\frac{\frac{dW}{dt}}{P}-\frac{\frac{dP}{dt}}{P}\frac{W}{P} \tag{4}$$

where W is the total wealth and P is the population. The symbol dW/dt constitutes 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 [40] makes preliminary empirical estimates of GS per capita for 110 developed and developing countries drawing on data from the World Bank's *World Development Indicators* series. 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% p.a. to 1.0% p.a., *ceteris paribus*, is sufficient to push GS per capita below zero. Moving on to the international part of the study, most developing countries with low per capita income have negative GS per capita. The exception is China, which displays robustly positive GS despite its relatively low per capita national income. This pattern reflects the result of the World Bank studies mentioned earlier – i.e., it is the countries of Sub-Saharan Africa, the Middle East, and Northern Africa that have the most negative GS per capita. Clearly, then, having negative GS on aggregate automatically translates into negative GS per capita (unless population growth is negative). Crucially, however, some countries with positive GS on aggregate have negative GS per capita. Examples include Jordan and Niger for whom 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 as outlined above. Dasgupta [8] and Arrow et al. [41] 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 [15] puts it, following this reasoning makes instantaneous well being (which is what point estimates of GS measure) dependent on the population size. This is the position of 'total utilitarianism'. A simplified version of Arrow et al.'s GS per capita is therefore [41]:

$$\text{GS}=\frac{\text{net investment in capital (various forms)} + \text{population growth}}{\text{population size}} \tag{5}$$

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. [41] argue that this weighting is in keeping with the simple principle of treating people equally (discounting notwithstanding), and Dasgupta [8] has also shown that the alternative position of 'average utilitarianism' has its own implications that may not be ethically defensible [42]. 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, at least according to their derivation, is that it may not equal zero. If the above formula is applied, 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, the GS formula simply collapses to per capita GS as in Hamilton [40]. 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, the modified Arrow et al. method is the correct one. An alternative position on this debate is offered by Asheim [15], who argues that if one is interested in sustainability, then it becomes important to compare the level of utility per capita, irrespective of how population size develops. He suggests this viewpoint is in line with Pezzey's [4] arguments. 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 (4) is worthwhile.

4.4 Calculating natural capital depreciation

Section 2 indicated that the World Bank's method for calculating resource rents based on price minus average cost is problematic. We also pointed out that deducting natural capital depreciation from conventional net savings leads to a rather important policy outcome, that is, certain resource-dependent countries need to invest more of the proceeds of natural capital depletion into the formation of other forms of capital than they currently do. In an inter-temporally efficient economy, calculating the depreciation of natural capital is theoretically straightforward since it is equal to the so-called total hotelling rent given by [1,2,10,12,20,43]:

$$(P - MC) \times R \tag{6}$$

where *MC* is the marginal cost. Since data on marginal costs are very difficult to obtain in reality, the World Bank relies on average costs as in equation (3). That the World Bank's method might be flawed was revealed by its empirical results, some of which appeared superficially odd. Neumayer [44], in particular, has queried if the North Africa and Middle East regions truly displayed GS rates of up to –30% at the end of the 1970s, and if Saudi Arabia, a nation with reserves of oil and natural gas that are still enormous, plausibly had GS rates usually lower than –20% over most of the World Bank's 25 year measurement period. If these results are accurate, then the regions and countries in question would have consumed the better part of their total capital stock within a matter of decades, leading to economic collapse. Needless to say, this has not happened. In fact, the World Bank's method is just one of at least three. Of these, El Serafy [45–47] estimated natural capital depreciation according to the following formula:

$$(P - AC) \times R \times \left[\frac{1}{(1+r)^{n+1}} \right] \tag{7}$$

where r is the discount rate, and n is the number of remaining years of the resource stock. The value of n tends to be set equal to the static reserves to production ratio, which is the number of years the reserve stock would last if production remained equivalent to the base year. Comparing equations (3) and (7), 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. It follows that GS rates would, ceteris paribus, be more positive. The El Serafy method, in effect, partitions the rents from resource extraction into the 'user cost' of resource extraction – i.e., the share of resource receipts that should properly be considered as capital depreciation – and 'sustainable income' in the true Hicksian sense. The latter is the level of resource consumption that can be sustained indefinitely [48].

The rather important difference between the El Serafy method and the World 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 rely upon it [49]. Furthermore, the World Bank's method is 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 (i.e., 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.

Neumayer [44], in response to questioning the realism of GS results for certain regions and nations, has recomputed the World Bank's GS estimates using the El Serafy method. Applying a discount rate (r) of 4% p.a., the regions of Sub-Saharan Africa, North Africa, and the Middle East no longer exhibit negative GS. Most individual countries also passed from negative GS into positive GS, particularly those with large remaining resource 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 be classified as weakly unsustainable because of their unsustainable rates of natural resource extraction. Auty and Mikesell [50] provided similar results in the case of Indonesia.

All this seems to suggest that the El Serafy method is far superior to the World Bank's method, but this may not be true in all cases. The method is very sensitive to both r and n, and there are problems associated with arriving at both values [50]. What is the correct discount rate is always an open question, and taking a high value of, say, 10% p.a. leads GS rates to deviate even more from the Bank's estimates [44]. 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% p.a. or lower, and of n if it is around 20 years or lower. Scanning data from the US Bureau of Mines [51] tends to reveal that n lies between 20 and 30 in the case of many resources for many countries and so the World 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 World Bank's method are nonsensical, but otherwise the Bank's method can still be usefully regarded as imposing a conservative sustainability standard.

4.5 Accounting for environmental pollution

As previously mentioned, the World Bank estimates the depreciation of natural capital due to environmental pollution in terms of the total damage cost of national carbon dioxide emissions. Following Fankhauser [25], this is taken to be US$ 20 per metric tonne of carbon emitted. This is quite clearly a restrictive approach, indeed, the World Bank knowingly omits many other types of pollutants (including air pollutants such as sulphur dioxide, oxides of nitrogen and fine particulates, water pollutants such as faecal coliforms and ground contaminants such as heavy metals). The upshot of this may well be, among other things, that the WS of developed countries is over-estimated, as Hamilton and Atkinson's [20] results suggest. Hamilton and Atkinson estimate the damage cost of air pollution in the UK to be between 3% and 5% of GDP during the 1980s, enough to push the UK's GS below zero for most of the early 1980s.

The World 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 [20] and the World Bank apply the damage cost approach, whereby 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 [52]. In an optimal economy, the two methods should amount to the same; however, 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% 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 cost-benefit analyses (CBA). 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 [53]. Clearly this decision will exert a considerable influence on GS rates.

In fact, the above has a corollary in the case of accounting for resource extraction. For example, some observers have argued that the resources depleted in the developing countries of the 'South' for the purpose of consumption or capital accumulation in the developed countries of the 'North' should properly be debited from the national accounts of the developed country. Again, this adjustment significantly changes the nature of GS rates, being more positive for resource exporters and more negative for importers [54]. 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. In addition, the results should also affect policy making in the North. For example, Atkinson et al. [21] tentatively suggest that aid should be made concessional on developing countries currently recording negative GS pursuing more prudent policies vis-à-vis natural resources.

However, there is no real case for following the same logic in respect of environmental pollution. 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 World Bank values pollution. Also, from a practical perspective, it is easier and safer to calculate damage cost estimates based on national emissions rather than on ambient emissions concentrations.

5 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 WS paradigm. Admittedly, there have been moves towards dealing with the non-substitutability of natural capital within the GS framework. Atkinson et al. [55] 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 SS, then GS results are largely uninteresting.

Within the confines of the WS paradigm, we have praised GS as both a meaningful counterweight to GNP in the measurement of social welfare (understanding of course that GNP was never intended to be a measure of social welfare), and as an indicator with a direct (if one-sided) sustainability criterion. However, GS has a competitor in this respect, an indicator referred to as the Index of Sustainable Economic Welfare (ISEW) and its counterpart the Genuine Progress Indicator (GPI). Both have been touted as a substitute for Gross Product [56,57]. The ISEW is essentially an adjusted measure of gNNP. Without going into detail, it subtracts natural and man-made capital depreciation from consumption, and makes some original contributions by:

- adjusting private expenditures for income inequality
- subtracting what are considered to be 'defensive expenditures'
- adding the value of household labour.

It is tempting to classify the ISEW as an indicator of SS, since its proponents are also proponents of SS (particularly Herman Daly), but since the ISEW assumes environmental and non-environmental expenditures are straightforwardly additive, it is arguably an indicator of WS [1–3]. The interesting differences between it and GS are firstly that the ISEW attempts to include *intra*- as well as inter-generational equity. It does this by adjusting private expenditures and by deducting what it regards as 'defensive' expenditures that are normally taken to be a positive contribution in national accounting.

The results of empirical studies into the ISEW paint a more pessimistic picture in comparison with GS. From the 1970s or early 1980s onwards, the ISEW in developed countries rises more slowly than gross product or even falls (e.g., [60] for the UK and Sweden; and [61] for the USA). This divergence tends to be described by the so-called 'threshold hypothesis', whereby economic growth is decoupled from quality of life. However, the problem with the ISEW is that it is not clear exactly why. Put another way, the policy implications of such a result are ambiguous because many different policies could raise the ISEW. In addition, the striking result of ISEW studies on developed countries – i.e., that total welfare is in fact falling – is vulnerable to the methods used to calculate defensive expenditures, natural resource extraction, and the damage costs of environmental pollution [3,62]. Using more plausible methodologies, threshold effects tend to disappear. We conclude that GS is preferable on theoretical and empirical grounds to its chief contemporary – the ISEW – and that it is more apt to guide policy. As far as measuring WS is concerned, GS is our leading candidate.

We will finish by reconsidering the various drawbacks to estimating GS. In light of them, the ultimate question is what value lies in GS from a policy perspective. The thrust of Section 4 is that GS is a very rough measure of sustainability. The assumption of an inter-temporally efficient economy is undoubtedly redundant, 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 shocks, then all prices, and in turn GS, have to be re-estimated. These are fundamental problems for GS, and we recommend that all GS estimates be accordingly interpreted with a great deal of caution. If one seriously objects to the optimality assumption, then the so-called hybrid indicators that abandon the search for optimality and instead measure the economic cost of some given standard may be judged superior. However, we would not go so far. Although there is insufficient scope in the present paper, it should be noted that the problems apparent in the hybrid approach are no less grave [1,2,62].

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 little 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 the World Bank's main estimates of GS are reversed for some countries when 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 WS is attained. This may or may not be true. These countries are not especially resource-dependent, and do tend to invest significantly in capital formation. However, the inclusion of a more comprehensive range of environmental pollutants would undoubtedly drive GS downwards. The really interesting policy outcome that currently is difficult to ascertain with confidence is that some developed countries might be weakly unsustainable on the grounds of excess pollution.

At the present time, then, GS provides some interesting if *generic* policy guidance in the WS realm. 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.

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ISEW/GPI = $C_{adj} + P + G + W - D - E - N$ where C_{adj} is the private expenditure adjusted by income distribution (normally the Gini coefficient), P is the non-defensive public expenditures, G is the growth in capital and net change in international position, W is an estimate of non-monetised contributions to welfare such as housework and parenting, D is the defensive private expenditure on for example household pollution abatement, E is the costs of environmental degradation, and N is the depreciation of natural capital. GPI also deducts loss of leisure time and underemployment.

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