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Is Australia on a sustainability path? Interpreting the clues*

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Genuine savings is a conceptually valid one-sided indicator as to whether Australia is on a weak sustainability path (negative GS would warn that current welfare is unsustainable). The World Bank's adjusted net savings (ANS) data summarise the available evidence, and by this indicator Australia is muddling along, at best. ANS misses some important pieces of the picture – net depletion of water, soil and biodiversity, and most kinds of pollution damage – and thus overstates Australia's genuine savings performance. Weak sustainability can be promoted by getting the prices right, and piecemeal efforts are underway via regulatory approaches and resource/environmental markets of various kinds. Nevertheless, particular resource problems – habitat conservation, biodiversity, climate change and dryland salinity – are likely to also require strong sustainability approaches. A sustainable future involves pushing weak sustainability as far as the body politic permits, invoking precautionary instruments for specific resource crises, and nurturing policy processes that encourage the consensus-building that will be necessary to get it done.

Key words: adjusted net saving, genuine saving, getting the prices right, precautionary instrument, resource and environmental assessment, strong sustainability.

1. Is Australia on a sustainability path? Framing the question

Given that sustainability matters and is *a priori* uncertain, there are good reasons to maintain an account of Australia's sustainability status, to consult it regularly and to take corrective action when it seems indicated. Weak sustainability offers one approach to the Bruntland Commission's sustainability goal '... meeting the needs of the present without compromising the ability of future generations to meet their own needs' (World Commission on Environment and Development 1987). It combines a thorough-going utilitarianism with strong assumptions about substitutability in consumption and production – it is welfare that is to be sustained, and welfare can be sustained by maintaining the stock of aggregated natural and produced capital. The World Bank provides accounts of national adjusted net savings (ANS), where ANS is intended as an account (albeit incomplete) of genuine savings, and GS is a diagnostic for shortfalls in weak sustainability (World Bank 2006a).

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Despite some non-trivial conceptual difficulties with ANS (noted below), it makes sense to start an inquiry into Australia's sustainability status by examining the ANS accounts. In Australia's case, ANS has remained positive but small enough to motivate a deeper inquiry. ANS is an admittedly incomplete accounting, so I proceed to augment what can be learned from ANS with information gleaned from resource inventories and economic scarcity indicators of various kinds. Inquiring into Australia's sustainability status is necessarily a process of assembling and interpreting the fragmentary evidence that can be gathered. As it turns out, the clues do not support complacency.

If sustainability is an issue, what should be done about it? Genuine savings accounting is useful for keeping track, but does not translate readily into policy prescriptions. Policy tools typically are aimed at adjusting incentives to encourage desired outcomes, which suggests a major role for getting the prices right. However, the link between right prices (real and/or virtual) and sustainability is less secure than we would like. The mapping between right prices and weak sustainability is incomplete, and the political realities suggest the inevitability of stopping short of getting all the prices right. Furthermore, weak sustainability depends on very generous substitutability conditions that attract scepticism in some circles. All of this implies that after doing all we can to get the prices right, strong sustainability[1] instruments should be taken seriously for particular resources.

2. Weak sustainability: keeping track

2.1 Conceptual foundations of weak sustainability

Solow (1974) considered sustainability prospects in terms of a very simple abstract model. He asked whether a society that uses exhaustible natural resources could nevertheless maintain human welfare indefinitely. In his model, welfare was defined as aggregate consumption, the factors of production (natural resources, capital and labour) were specified also in aggregate terms, and the production function was Cobb–Douglas, implying that the elasticity of substitution among factors was constant and unitary. This structure is focused on aggregates and uninterested in particulars – it allows very generous substitution not only among but within the broad categories. Aggregate consumption and welfare can be maintained even as the mix of goods and services in the consumption bundle changes, perhaps dramatically; and, likewise, the composition of the natural resources, capital and labour aggregates may change much more radically than their aggregate quantities. All of this substitutability clearly enhances the prospects for sustainability, a rallying point for sceptics who argue for one or another form of strong sustainability

[1] Strong sustainability comes in a range of strengths, but all share the common element of concern that particular forms of capital should be maintained independently of the aggregate capital (natural and produced) maintained under weak sustainability.

as insurance against substitutability assumptions that turn out to have been disastrously optimistic. In effect, Solow grants special status to natural resources by assuming essentiality and exhaustibility, but immediately revokes it by assuming perfect substitution of produced capital for natural resources. In the end, natural resources are nothing special in this model.

Solow showed that, even with exhaustible natural resources, human welfare can be maintained for a very long time so long as accumulation of capital compensates fully for depletion of natural resources. His model is readily extended to show that this result can accommodate a growing population, so long as technical progress keeps up with population growth.

Solow's formulation provides the foundation for the economic literature on weak sustainability, which is attained by definition when human welfare per capita can be maintained indefinitely. Hartwick (1977) showed that consumption is sustainable in a fixed technology economy with an essential exhaustible resource, if net saving is everywhere 0 (which requires that capital accumulation compensates exactly for resource depletion), the elasticity of substitution between resources and capital is 1, and the elasticity of output with respect to capital is greater than the corresponding elasticity for the resource. The Hartwick rule derived from this result achieves zero net saving in an exhaustible-resource-dependent economy by requiring that the scarcity rents from natural resource depletion be re-invested in reproducible capital.

Dasgupta and Heal (1979) and Hamilton (1995) showed that if the elasticity of substitution between capital and natural resources is less than 1, then the Hartwick rule is not feasible – eventually production and consumption must fall, implying that the economy is not sustainable under the rule. This result underscores the dependence of weak sustainability on generous substitutability of capital and natural resources.

2.1.1 Genuine saving

The crucial role of zero net saving focuses attention on developing a system of accounts capable of tracking net saving of capital and natural resources. An ideal capital accounting system would tell society whether it is satisfying the Hartwick rule. Pezzey and Toman (2002, pp. 184–185) show that genuine saving, GS (an ideal account of net savings in a resource-using economy) provides a one-sided sustainability test in the Hartwick tradition – with negative GS, there must be negative welfare growth at any instant.[2] The opposite is not true in general – positive saving at a point in time does not indicate that future utility is everywhere non-declining. However, Hamilton and Hartwick

[2] The green accounting tradition, which aims to correct national accounting systems by adjusting for resource depletion, environmental damage, and so on, is closely related in principle (if not in all analytical details) to genuine savings accounting. For example, Asheim and Weitzman (2001) show that growth in green net national product (where prices are deflated by a Divisia index of consumption prices) indicates the change in welfare in the economy, and Pezzey and Toman (2002, pp. 182–186) develop the linkages between changes in green net national product, genuine savings, and sustainability.

(2005) show that positive genuine saving is a component of a feasible weak sustainability prescription.

Genuine saving at any time t is the sum of the changes in stocks of each of the various kinds of natural and produced capital, each weighted by its virtual price:

$$GS_t = \Sigma p_{it} \cdot \Delta K_{it},$$

where $i = (1, \ldots, n)$ is an exhaustive list of the various forms of capital with virtual prices p_i. Getting these virtual prices right matters – GS can provide a sustainability indicator only if it is calculated using the right prices. In this context, there are two dimensions to the concept of right prices: the familiar notion that observed prices should be adjusted to correct for market distortions, externalities and public goods; and the fundamental caveat that GS is a valid sustainability indicator only if it is based on sustainability prices, which can be observed only after sustainability has been achieved (Pezzey and Toman 2002; Cairns 2006). The K_i include gross national saving, net investment in human capital, depreciation, depletion of minerals and energy, net depletion of forests, net depletion of water resources in terms of quantity and quality, depletion of biodiversity, net pollution damage (including damage from greenhouse gases (GHG)) and net degradation of soil.

2.2 Australia's ANS situation

There is a lot to be learned by consulting an ideal account of Australia's genuine savings The World Bank has attempted to compile and maintain GS accounts for a broad array of countries.[3] The result is a downloadable spreadsheet of ANS for 212 countries, with annual entries beginning in 1970 for many of them (World Bank 2006a).

ANSs include gross national savings, educational expenditures, depreciation, mineral depletion, energy depletion, and damage from carbon dioxide and fine particulate emissions. It falls short of an ideal account of GS in several respects: educational expenditures is an unsatisfactory proxy for net investment in human capital, damage from CO_2 and fine particulate emissions captures only two among many categories of pollution damage, net forest depletion data are missing for most countries (including Australia), and there is no attempt to account for depletion of water, biodiversity and soil.[4] Nevertheless,

[3] Brown *et al.* (2005) provide a detailed discussion of the evolution of GS, its weaknesses and the improvements that can be (and in some cases have been) made in GS accounting. They also show what can, and cannot, be accomplished in disaggregating the Australian ANS accounts to the state (in their case, Queensland) level.

[4] Pezzey and Toman (2002, pp. 186–190) illustrate the challenges of applied sustainability accounting in a simple model economy, and the detailed attention required to do even a passably credible job.

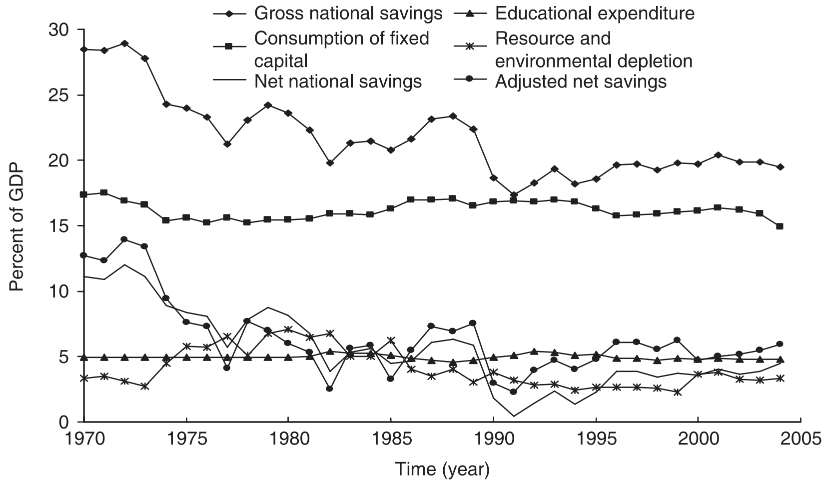

Figure 1 Composition of adjusted net savings, Australia, 1970–2004.

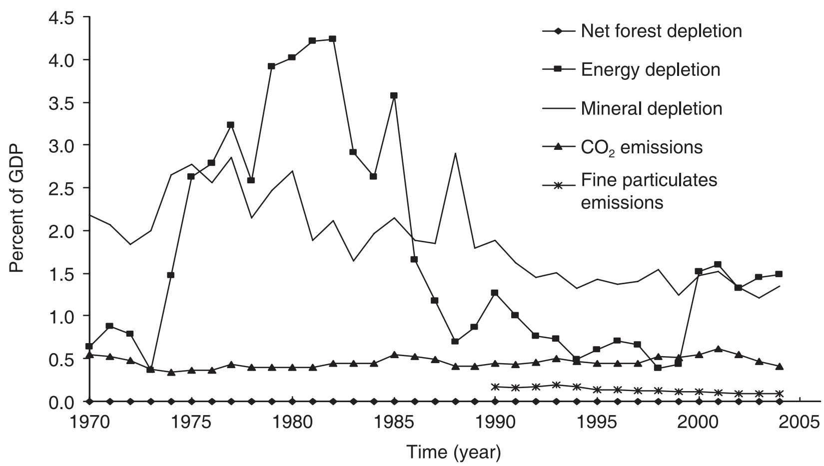

Figure 2 Composition of resource and environmental depletion, Australia, 1970–2004.

it is the best available accounting of GS in a form that facilitates cross-country comparisons.

For Australia (Figure 1), we see a secular decline in ANS since 1971, levelling-out and perhaps recovering a little since 1990. ANS has followed roughly the pattern of gross national savings, but has been influenced also by some volatility in resource and environmental depletion (RED). Energy depletion and mineral depletion account for the bulk of RED (Figure 2), and show greater volatility than emissions (CO_2 and fine particulates).[5] The pattern of declining

[5] A caveat: Common and Sanyal (1997) show that calculations of Australia's depreciation of non-renewable natural resources following different measures yield strikingly different results.

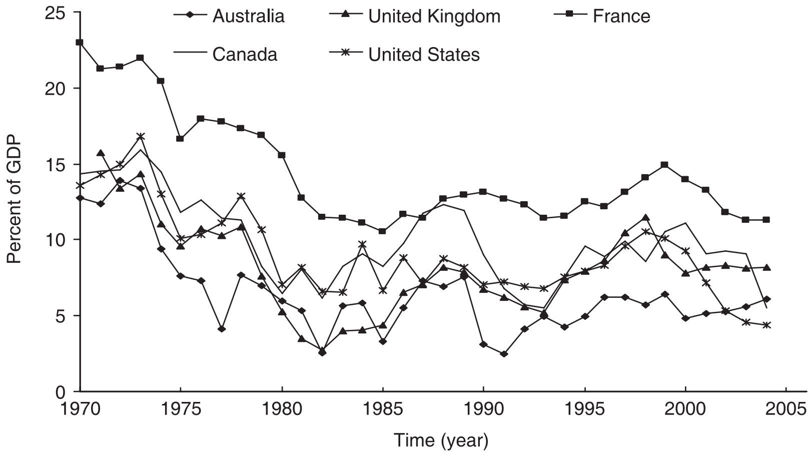

Figure 3 Adjusted net savings, selected OECD countries, 1970–2004.

ANS in the last third of the 20th century seems typical of the rich countries (Figure 3), but for most of this period Australia leads a comparison group that includes France, Canada, the United States and the United Kingdom, in the extent of its relative decline.

Because ANS is in practice an imperfect sustainability indicator, this evidence of declining ANS should be interpreted cautiously. Nevertheless, it may be a warning signal, because ANS predicts future welfare (Ferreira and Vincent 2005; Hamilton 2005; Hamilton and Bolt 2007). Specifically, these authors show that ANS in 1980 is positively correlated with the present value of changes in gross domestic product from 1980 to 2000, for a broad cross-section of countries. Ferreira and Vincent (2005) note that the correlation is better for non-OECD countries, and the fit improves as better measures of GS are tested.[6]

There is a strong negative correlation between dependency on exhaustible resources and ANS, to the extent that highly resource dependent countries tend to have negative ANS (Hamilton and Bolt 2007). If mineral and energy dependent economies were diligently investing their rents in other types of capital, as the Hartwick rule prescribes, then there should be no apparent link between resource dependence and genuine saving. Instead the evidence suggests a tendency to consume resource rents that increases with resource dependence.

Consider a more diverse comparison group that includes a rapidly growing lower middle income country (China), a middle income country with a substantial oil extraction sector (Venezuela) and Saudi Arabia, which is highly

[6] In this respect, it is noteworthy that the adjustment for educational expenditure performs poorly.

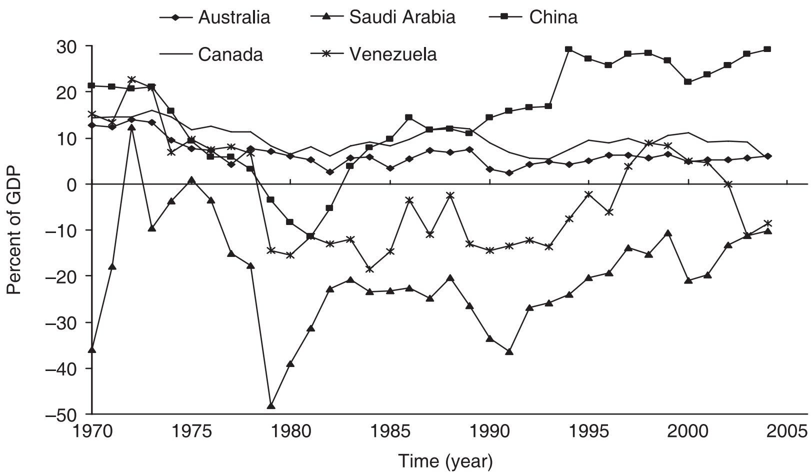

Figure 4 Adjusted net savings, selected countries, 1970–2004.

dependent on oil extraction (Figure 4). To accommodate these countries, the range of the ANS axis has to be expanded. China has maintained ANS rates above 20 per cent since 1993 and Saudi Arabia has experienced negative ANS in all but one year, with several observations below –30 per cent. Venezuela, while exhibiting substantial volatility, has had mostly negative ANS since 1979.

2.2.1 Human, social and institutional capital

The ANS accounts exhibit perhaps their greatest weakness in their treatment of intangible (i.e. human, social and institutional) capital, which they proxy by educational expenditures, a variable that performs poorly, as noted above. Contrast this with the World Bank's accounting of national wealth (2006b,c). The characteristic pattern in wealthy countries is that intangible wealth accounts for more than 80 per cent, and natural wealth less than 5 per cent, of all wealth.[7] It seems scarcely credible that educational expenditures provide an adequate account of net additions to this vast stock of intangible capital. Yet, we know how important intangible capital is – accounting for technological change (which is generated by intangible capital) moved an account of Scotland's GS from an unsustainable reading to the sustainable range (Pezzey *et al.* 2005).

France, the United Kingdom and the United States exhibit the characteristic pattern of wealthy countries: intangible capital exceeds 80 per cent of all capital, while natural capital accounts for less than 5 per cent (Figure 5). Australia and Canada are more natural-resource-dependent than most wealthy countries,

[7] However, it must be understood that intangible capital is measured by inference – the residual GDP that cannot be attributed statistically to other, more readily measurable factors is attributed to intangible capital, and is then capitalised.

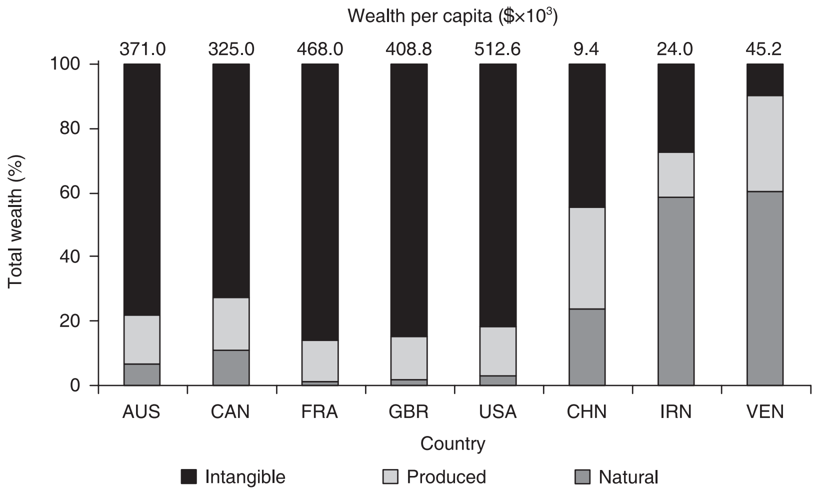

Figure 5 Composition of wealth, selected countries, 2000.

but natural capital is still less than 10 per cent of all capital. Along with much lower wealth per capita, we see much lower proportions of intangible capital in China, Iran and Venezuela.[8] The World Bank has quantified Australia's natural capital, in terms of subsoil assets (mainly minerals), which account for 47.5 per cent of natural capital, farmland (the sum of cropland and pasture land), which accounts for 41.2 per cent, and timber resources, non-timber forest resources, and protected areas, which account for the remainder. Unfortunately for our purposes, annual changes in these capital stocks are not captured in the ANS accounts.

2.2.2 Summary

From a weak sustainability viewpoint, the available data suggest that Australia is muddling along with ANS in the 5 per cent range (Figure 3). It is doing better than many resource exporting countries (the negative savers) but not so well as Canada, whose economy is similar in many respects: modern and diversified, but more dependent than many such countries on exports of natural resources and agricultural commodities. Canada's ANS has consistently exceeded Australia's, often by a substantial amount (although the two series appear to converge in 2004, the last year for which there is data).

Can Australia take comfort in its consistently positive, if small ANS rate? The evidence concerning this crucial question is far from complete. We know that the ANS data provide better measures for some kinds of saving than others (e.g. education expenditure is a poor measure of investment in

[8] Iran, rather than Saudi Arabia, represents the oil-rich countries in Figure 5. No sleight of hand is intended – the ANS data series is more complete for Saudi Arabia whereas the wealth data series is more complete for Iran.

intangible capital), and there are important omissions in the accounts of natural/environmental resources. To make progress, it will be important to identify the missing categories and interpret the available evidence, fragmentary as it may be.

2.3 ANS – tracking down the missing pieces

The obvious categories of natural and environmental resources that are missing in the ANS accounts are net depletion of forest resources (for many countries including Australia), net depletion of water resources (quantity and quality), depletion of biodiversity, most kinds of pollution damage (there are attempts to measure damage from CO_2 and fine particulate emissions) and net degradation/enhancement of soil resources.

In practice, tracking down the missing pieces is mostly a matter of interpreting fragmentary evidence: looking for clues. Our search for clues focuses on agriculture, natural resources and environment, because these are the areas most under-represented in the ANS accounts.

2.3.1 Productivity of agriculture is increasing

If Australia is experiencing net depletion of its agricultural resources, this has not been reflected in agricultural productivity. As conventionally measured, agricultural productivity has exhibited strong growth over the longer term. Multifactor productivity has grown about 2.3 per cent annually since 1975 in agriculture (more than double the rate for the whole Australian market sector), and productivity growth has accelerated since 1995. Furthermore, the entire increase in agricultural output over the last 30 years has been accomplished with no systematic increase in conventional factor use, and has been attributed to increased factor productivity (Productivity Commission 2005).

However, we must ask also about the resource and environmental cost that has accompanied this vigorous growth in conventionally measured productivity. A more complete accounting would attend to changes in stocks of land and related assets, and flows of environmental services as affected by agriculture. To assess these changes, and changes in other natural and environmental resources, we turn to the recent series of comprehensive resource assessments for Australia that provide extensive information of a mostly physical kind.

2.3.2 Clues from resource assessments

Water. More than half of Australia's current surface water use occurs in areas where water is fully committed or overcommitted and overused. Thirty per cent of groundwater management units are fully or overcommitted. Evidence of water supply problems becomes more compelling when we factor-in ecological requirements for in-stream flow, a concern that Australia has recognised rather late in the game. Stress on water resources is increasing rapidly – a 65 per cent increase in water use nationwide was recorded in a recent 10-year period (*Australian Water Resources Assessment 2000*). Since surface water use was capped in 1995, increasing groundwater use has placed unprecedented pressure on reserves (Department of the Environment and Water Resources, DEWR 2006).

Surface water quality data are incomplete, but major exceedances of standards for nutrients and turbidity were found to occur in 60 per cent of the basins that have been assessed. Salinity exceedances were found in one-third of the basins assessed, most prominently in basins within the Murray–Darling and the South-West Coast Drainage Divisions. Despite seriously limited data, there is evidence of groundwater quality problems in some basins. In summary, the fragmentary evidence available suggests net depletion and degradation of Australia's surface and groundwater resources (*Australian Water Resources Assessment 2000*).

Forests. Big-picture trends are that the area in plantation forests is growing, and almost 60 per cent timber removed annually now comes from plantations, while the area of native forests is declining due to land clearing. However, the rate of land clearing has decreased in recent years, and policies are in place to reinforce this trend (DEWR 2006). From the perspective of wood and timber supplies, the evidence seems to point toward sustainability (*Australia's State of the Forests Report 2003*). However, Australia's forests also provide many ecological services, some of which are threatened by land clearing.

Biodiversity. Almost 3000 threatened ecosystems and other ecological communities have been identified nationwide. Most bioregions (94 per cent) have one or more threatened ecosystems, and nearly half of the threatened ecosystems are eucalypt forest and woodlands with shrubby or grassy understorey that have been extensively cleared. There is evidence that the condition of mammal species, wetlands and riparian zones is declining (*Australian Terrestrial Biodiversity Assessment 2002*). The *Australia State of the Environment 2006* report (DEWR 2006) highlights declines in riparian vegetation and populations of frogs and waterbirds.

Soil depletion and degradation. Concerning the traditional threats to agricultural soil resources, nutrient depletion and soil erosion, the evidence is mixed – there are gains from nutrient build-up in agricultural soils, as well as losses from continuing soil erosion (*Australian Agriculture Assessment 2001*). More recently, dryland salinity has been recognised as a potentially serious threat to soil resources. Currently, regions affected by dryland salinity or at risk include approximately 5.7 million hectares. Roughly two-thirds of land at risk is classed as agricultural, but dryland salinity threatens native vegetation and ecosystems, too. Salt also damages infrastructure, sharply reducing its useful life. Estimates suggest that by 2050 the area facing high salinity risk may triple (*Australian Dryland Salinity Assessment 2000*). While projections framed in terms of resources at risk may overstate future impacts, it is clear that dryland salinity is a continuing source of net soil degradation.

Atmospheric resources. Depletion of atmospheric resources falls into three categories: (ordinary) air pollution, ozone depletion in the upper atmosphere and accumulation of GHGs. There are forces increasing emissions (increased economic activity) and reducing them (emissions controls of various kinds), and the 2006 assessment reports reduced sulphur oxide concentrations and fewer ozone episodes in recent years (DEWR 2006). The fragmentary evidence available is unclear as to whether net depletion of air resources is currently occurring on a national scale.

There is some good news, in the form of evidence that the size of the Antarctic ozone hole has stabilised and amount of ozone in the stratosphere has increased in recent years (DEWR 2006).

Average surface temperature in Australia has increased by 0.82°C since 1910, which is consistent with the global temperature increase of 0.6–0.7°C (DEWR 2006). The warmest years on record have been observed since 1990–2005 was the warmest single year (*Annual Climate Summary 2005*) – and the frequency of extreme warm days and nights has increased while the numbers of extreme cool days and nights have decreased. Australia's GHG emissions continue to increase, and high quality data show that GHG concentrations are increasing more rapidly in recent years than at any time in the past 1000 years (DEWR 2006). The pattern of rising temperatures, in the context of a burgeoning body of modelling and observational evidence, suggests that increasing GHG emissions threaten on-going degradation of climate resources.

2.4 Economic indicators

It makes sense to look also for economic evidence of resource and environmental depletion. There is a long tradition of tracking resources prices (better yet, rents) as scarcity indicators. Gangadharan and Maitra (1998) report that there is no discernable trend of increasing prices for Australian resource commodities. This kind of analysis, going all the way back to Barnett and Morse (1963), has often generated results of this sort. However, the conclusions that can be drawn are limited – first, prices may move in a different direction than resource rents if, for example, there are systematic cost-saving advances in technologies for discovery and extraction; and second, for many resource commodities Australia is a net exporter, so trends in prices set in world markets may mask the particularities of the Australian sustainability situation.

Prices observed in water markets might in principle provide another perspective on scarcity of water. But this evidence is less illuminating than one might hope. Water markets are mostly for seasonal rentals rather than transfer of rights, and are relatively thin. There is some evidence of rising water rental prices, but the considerable volatility of prices tends to mask trends (Bjornlund and McKay 2002).

Thampapillai *et al.* (2003) and Thampapillai and Thangavelu (2004) provide an empirical analysis (that I interpret as) showing that factor intensity of air, as a sink for waste, in Australia's aggregate production is decreasing. This means that use of air as environmental capital is becoming more efficient, a trend that if maintained would allow economic output to increase (at some rate that could in principle be calculated) without diminishing air quality.

At a more aggregate level, evidence has been assembled that Australia's environmental capital is becoming increasingly scarce (Thampapillai 2005). Mallick *et al*. (2000) have calculated that Australia's levels of real wages and employment are unsustainable. Solutions include reducing real wages and employment, reducing real wages more drastically so as to maintain employment or reducing the factor-intensity of environmental and natural resources in Australia's production of goods and services.

Imagine we knew that factor intensity was decreasing over time, not only for air resources, but also for land clearing, irrigation water, nutrient effluents in surface water and GHG emissions. If this were true, it would provide considerable comfort for weak sustainability advocates, because it would suggest that aggregate consumption can be sustained over time with diminishing pressure on environmental resources. This is an interesting prospect, with some intuitive appeal to those who believe that technology can and does respond to increasing scarcity of environmental resources. However, we do not yet have the empirical evidence to support such a claim across a broad front.

2.5 The evidence suggests that genuine savings in Australia is systematically lower than ANS

This broadbrush examination of the evidence – mostly physical rather than economic, and fragmentary as it is – offers some clues that genuine savings in Australia is systematically lower than ANS. First, the good news: timber resources in aggregate do not appear to be experiencing net depletion, and the 'ordinary' problems with atmospheric and soil resources – air pollution, soil erosion and nutrient depletion – do not appear to be getting worse. So, the clues do not suggest that omission of these items distorts the genuine savings picture presented in the ANS accounts.

However, there is bad news, too. Water resources are overused, overcommitted, and of diminishing quality; and demand is growing exuberantly. Dryland salinity and GHG emissions/climate change are growing concerns, and biodiversity – especially in eucalyptus/acacia ecosystems, wetlands and riparian ecosystems – is diminishing. We appear to be on safe ground concluding that omission of changes in water quantity and quality, dryland salinity and biodiversity in the ANS accounts do in fact distort the picture of genuine savings. ANS attempts to account for GHG accumulation, but the difficulties of so doing tend to limit the confidence we can have in this accounting.

In summary, it seems clear that genuine saving in Australia is systematically lower than ANS. Given that ANS was below 5 per cent in 2000, it is reasonable to question whether Australia's genuine savings are positive.

3. Instruments for sustainability

In the event that the weak sustainability accounts sound a warning, what follows? What would a package of policy responses in support of weak sustainability look like? As it happens, the logical linkage between a weak sustainability warning and the appropriate response is not as robust as we might want. Weak sustainability is all about maintaining consumption and welfare, and the Solow–Hartwick tradition identifies net savings as the key. So, GS accounting is all about keeping track of net savings. But Solow asked only about whether a sustainability constraint could be met, not about whether an economy can be constructed (or imagined) that autonomously achieves sustainability. The point is that the Solow–Hartwick tradition is uninformative about sustainability prices – the prices (including the interest rate) that would motivate rationing, production, saving and investment decisions consistent with weak sustainability. Furthermore, a fundamental caveat has been raised by Pezzey and Toman (2002) and noted above (Section 2.1) – the Hartwick rule cannot offer an exact policy prescription for sustainability in the real world, because observed prices are not generated by an underlying sustainability objective function (to put it another way, sustainability prices can be observed only once sustainability has been achieved).[9]

So it involves a little flying by the seat of the pants, to identify getting the prices right as a key component of weak sustainability policy. Nevertheless, there is some intuition to support such a leap of faith. Missing prices, and prices seriously below social costs, encourage wasteful consumption and under-conservation, and surely undermine sustainability.

3.1 Getting the prices right

It turns out, unsurprisingly, that the many of the resources in apparent negative balance are among those with rich histories of government and market failure. Water supply for urban and irrigation uses has a long and convoluted history of government failure in Australia, with predictable consequences of over-allocation and inefficiency. The relatively poor performance regarding water pollution (especially from agricultural sources), biodiversity, GHG emissions, and dryland salinity is consistent with the susceptibility of these resources to externality and public goods problems.

[9] There is another issue that I prefer to relegate to a footnote. Various authors have noted what they consider a troubling inconsistency between sustainability accounting, which seeks to maintain (undiscounted) consumption and welfare, and the standard economic model, in which actors seek to maximise the present value of discounted welfare (Harris and Fraser 2002; Pezzey and Toman 2002). I am not so troubled, for reasons explained elsewhere (Randall 2006). Briefly, utility discounting is not essential to generate positive interest rates in an economy with overlapping generations. All that is needed is productive capital and actors who are capital-poor when young but accumulate capital as life goes on, seeking only to maintain constant utility over their lifetimes (Farmer and Randall 1997). Given that utility discounting is not essential to explain persistent positive interest rates, I am not so sure that it should be uncritically assumed in intertemporal economic modelling.

For government failure, which is prominent in the area of water supply, the textbook solutions are efficient administered prices and market-based instruments (MBIs). For market failures, the toolkit has evolved in recent years. Traditionally, it featured regulation and Pigovian pricing, while policy practice favoured regulatory approaches. For a variety of reasons, ranging from the practical to the ideological, regulation by design standards has lost favour in recent years while MBIs and non-mandatory instruments (NMIs) are gaining support. These categories are not mutually exclusive – for example, a strong regulatory stance often provides the essential motivation for successful MBIs.[10] Furthermore, the devil is always in the details – it is possible to do regulation well, and to do Pigovian pricing or MBIs badly; and, despite incentives that are complex rather than simple and come in shades of grey rather than black and white, there is some empirical evidence that NMIs can be effective (Anton *et al.* 2004).

3.1.1 Particular resources under stress – prospects for getting the prices right

Australia has been active in developing and piloting MBIs, and in some cases implementing them at scale. Water markets have led the way. The Murray–Darling basin provides an informative case study, because that is where scarcity is most pressing, water supply and quality issues are most thoroughly entangled, and government failures (patchwork entitlements, administrative rigidities and user fees largely unrelated to the cost or value of water) have been most pronounced. Water markets have developed since 1983, within a strong regulatory and administrative environment (Bjornlund and McKay 2002). Despite continuing evolution toward less restricted markets, Shi (2005) documents the complex matrix of entitlements that continues to impede trade. Actual trading has been restricted to agricultural uses. Most trading has involved flow rentals, which have accounted for up to 20 per cent of annual allotments in the three major irrigation districts of the Murray–Darling basin in some years. Permanent sales of entitlements have thus far accounted for less than 2 per cent of flows. Transfer volume has increased in recent years, for both rentals and entitlements (Grafton and Peterson 2007). Only 13 per cent of river basins have environmental flow plans; many others have temporary in-steam flow requirements.

It is clear that, thus far, water markets have barely begun to accomplish their real task – reallocating massive quantities of water to higher-valued uses, to accommodate economic growth in a system in which over-allocation and overuse is endemic. The National Water Initiative is a serious effort to achieve a nationally compatible market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use (COAG 2004; Grafton and Peterson 2007).

[10] The success of cap-and-trade programs (for example, the US market in sulphur oxides emissions reduction credits) depends crucially on the regulatory cap on total emissions.

Beyond water markets, we find a few operating markets in pollution reduction credits (the Hunter River salinity market, and the South Creek bubble), and a larger number of MBIs in the proposal and pilot study phases. In the Bush Tender pilot projects, contracts have been auctioned (there is no after market), which revealed previously hidden information about farmers' willingness to supply habitat protection. On the other hand, demand remains obscure (government is presumed to know the public's demand), and incentives for actual farmer performance are incomplete (Bardsley 2003). The problem of hidden action is a generic issue for those MBIs where commitments to implement particular practices, rather than to produce measurable results, are traded.

The National MBI Pilot Program has sponsored 11 pilot projects, including auctions of conservation contracts, cap-and-trade mechanisms and offset programs, with application to biodiversity and habitat conservation, salinity, water quality, carbon and wind erosion (NMBIWG 2005). There have also been developments in the area of NMIs, including the Greenhouse Friendly label, the Water Efficiency label and, on a higher scale of complexity, the Landcare program.

The bottom line is that, while progress is clearly being made in resolving some long-standing market and government failures involving natural resources and environmental amenities, getting the prices systematically right is beyond reach for several reasons. Pigovian taxes are seldom on the political agenda, while regulation by design standards is losing rather than gaining momentum. MBIs and NMIs are all the rage, but there are important caveats. Cap-and-trade programs encounter political hurdles (caps are not always politically feasible). Conservation auctions of various kinds, and pollution trading networks that include farmers as sellers of credits, are popular because they deliver money (often to farmers), but delivery of environmental performance is less assured. For these reasons and more, we are likely always to stop short of getting all the prices all-the-way right – and to stop short of achieving positive balances in the natural resources and environmental lines of our weak sustainability accounts.

Climate and GHG, and dryland salinity present particular challenges. The climate problem cries out for global carbon/GHG taxes or, better yet, a global cap-and-trade system. However, global political capital presently falls far short of what would be needed to make that happen. Dryland salinity raises a different kind of challenge. First, it is an exhaustible-resource problem – even if the factor intensity of salinisation in producing agricultural output was decreasing, it would mean only that we are 'mining the soil' a little more slowly. Second, the extent of the market failures involved in dryland salinity is unclear (Pannell 2001; Bathgate 2002). Frankly, while certain salinity-controlling practices are profitable in particular cases, strong prevention and mitigation measures on a large scale are unprofitable at any realistic discount rate. For this reason, balancing the weak sustainability accounts may be a matter mostly of encouraging compensatory savings and investment elsewhere in the economy to compensate for the on-going disinvestment in dryland soils.

3.2 Are weak sustainability policies enough?

For particular resource/environmental problems – water supply, timber, soil erosion and nutrient depletion, air pollution, and the more tractable sorts of water quality problems – it can be argued that getting the prices right would take us a long way toward weak sustainability. But it is well to remember that even weak sustainability asks us to do much more than we are doing now. For habitat conservation and biodiversity, getting the prices right is likely at best to be only a part of the solution. These problems are likely to require attention to specific resources in particular cases. For GHG and climate, we must recognise first that we are a very long way from systematically getting the prices right. The prices that matter include virtual prices for global public goods, and getting that right is no easy task for economics, politics and diplomacy. Failing that, weak sustainability policies offer only the prospect of adapting to climate change in ways that are unlikely to sustain welfare.

Dryland salinity highlights the distinction between weak and strong sustainability. Given the unprofitability of large-scale measures to control and mitigate dryland salinity, weak sustainability demands only that compensatory savings and investment elsewhere in the economy balance the disinvestment in dryland soils. Strong sustainability focuses not just on maintaining future welfare but on the resource itself, demanding that the soil be saved or (depending on the particular strong sustainability formulation) that losses in soil resources due to salinisation be offset by compensating investments in soil improvements elsewhere.

The bottom line is that political impediments and challenges in mechanism design are so substantial that solutions in the real world are likely to involve some continuing shortfalls in getting the prices right, which will adversely affect the balances on the natural resource and environmental lines of the weak sustainability accounts. The policy matrix is likely to feature some continuing deviations from systematic efficiency (but perhaps fewer than we have now), shored-up with piecemeal application of strong sustainability instruments, for example, precautionary instruments aimed at maintaining stocks of particular kinds of natural and environmental capital.

4. Concluding comment

Weak sustainability seems to be the least we could aspire to, if we accept a serious commitment to the future. Yet, Australia's weak sustainability situation seems precarious at best, and while progress is being made toward getting the prices right (which would encourage weak sustainability) complete success remains unlikely. Strong sustainability instruments are likely to be a part of the solution, to shore-up cases where there is stubborn resistance to getting the prices right, and to deal with particular conservation priorities where the risks are perceived to be asymmetric.

Elsewhere, I have argued for a framework that would prescribe weak sustainability policies for business-as-usual, with strong sustainability exceptions for particular, credible threats of resource exhaustion (Randall 2007). Such a framework would respect both the modern experience of technical progress and increasing welfare even as substitution in production and consumption proceeds apace, and the reasonable instinct for caution as we continue to push at the frontiers of what can be known about our planet's capacity to support future welfare. A challenge that remains is nurturing policy processes that encourage the consensus-building that will be necessary to design and implement such a framework.

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