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Cost-Benefit Analysis and the Environment
Recent Developments
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Chapter 16

Sustainability and Cost-benefit Analysis

The notions of sustainability and "sustainable development" have permeated significant parts of policy and public discourse about the environment. This chapter discusses the handful of recommendations do exist with regards to how CBA can be extended to take account of these concerns. One perspective starts from the assertion that certain natural assets are so important or critical (for future, and perhaps current, generations) so as to warrant protection at some target level. In terms of the conduct of CBA, this has resulted in the idea of a shadow or compensating project, meaning that projects that cause environmental damage are "covered off" by projects that result in environmental improvements. The overall consequence is that projects in the portfolio maintain the environmental status quo. More broadly, the sustainability debate has focussed attention on assets and asset management. This might emphasise the need for an "asset check". That is, what the stocks of assets are before the project intervention and what they are likely to be after the intervention?

16.1. Introduction

The call for countries to pursue policies aimed at achieving "sustainable development" or "sustainability" was established in the Brundtland Report in 1987, the Earth Summit in 1992 and, more recently, at the World Summit in 2002. Sustainable development has been now adopted as an over-arching goal of economic and social development by United Nations agencies and by many individual nations, local governments and even corporations and further has generated a huge literature. It is clear that formidable challenges confront policy-makers who have publicly stated their commitment to the goal of sustainable development; not least in determining what exactly it is that they have signed up to. Most fundamentally, however, most discussions about sustainability typically have centred upon establishing a wider understanding of our obligations to future generations and identifying the actions implied by observing these obligations. The subject of this chapter is how such concerns about *intergenerational* equity can be integrated into the appraisal of public projects.

Not surprisingly much of the early literature reflected debates about whether to "discount" or "not discount". That is, what is the appropriate way in which we should weigh costs and benefits that occur in the future relative to the present? A familiar argument was that social discount rates typically used by, for example, finance ministries and development agencies were "too high". Many worried that this created, in effect, an in-built bias against projects which entail substantial up-front costs but benefits coming on-stream only in the distant future, with climate change mitigation options perhaps being the pre-eminent example. While these debates are far from wholly resolved, there is arguably a consensus that at least some of the proposed cures for this dilemma – such as using a zero social discount rate – may actually make matters worse in other directions. Moreover, recent developments in the literature on social (and private) discounting – reviewed in Chapter 13 – have provided a more level playing field for appraising projects with impacts in the far-off future.

The objective of this chapter then is to review a variety of more recent proposals for how cost-benefit analysis (CBA) might be interpreted in the light of concerns about sustainability. It is worth noting at the outset that some have been altogether more critical of the applying the concept of sustainability to CBA. Little and Mirrlees (1994), whose pioneering theoretical work has been a guiding light in the modern application of cost-benefit thinking to the appraisal of projects, is one example. Their criticisms are two-fold. First, they argue that sustainability is "more of a buzzword … than a genuine concept" (p. 213). Second, they view sustainability as flimsy grounds for accepting or rejecting projects in that it would rule out, almost by definition, some productive activities such as mining.

With regards to the former charge, while there remains some debate about what precisely "sustainability" means (or what it means for development to be sustainable), in the past decade or so there has been remarkable and genuine progress in understanding

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the concept of sustainability both in theory and in practical terms (see, for recent and comprehensive reviews, Pezzey and Toman, 2002; Hamilton and Atkinson, 2006). Of course, a number of debates still exist. Nevertheless, most would argue that sustainability is a meaningful concept.

That claim, however, says nothing in particular about how this concept affects project appraisal and cost-benefit thinking more generally. Hence, the second charge brought by Little and Mirrlees, needs careful consideration. On the one hand, critics might argue that the best way in which policy-makers can contribute to sustainability is by selecting the best projects, where "best" is defined relative to a standard cost-benefit test. Furthermore, if we define sustainability concerns as synonymous with greater environmental protection (it is more complicated than this, as we shall see below) then, relative to the case where non-market or intangible environmental impacts are ignored, proper shadow pricing will reduce the number of environmentally damaging projects within a portfolio (relative to the case where non-market environmental impacts are ignored by analysts). Put another way, simply conducting a proper state-of-the-art CBA of projects could have a favourable impact on prospects for sustainable development.

On the other hand, these comments by no means capture the entirety of the sustainability debate, which crucially is concerned about the distribution of well-being (or net benefits) over time. Establishing methods that permit the routine shadow pricing of environmental impacts is just one piece of the puzzle in understanding intergenerational consequences of project selection. Other prominent aspects of the sustainability debate focus on whether projects, in the aggregate, are creating enough wealth for future generations as well as arguing for a more specific focus on whether enough *natural* wealth is being conserved. One concern is that too many "projects" involve the current generation enjoying benefits now (or in the near future) at the expense of those living in future generations. What this amounts to is a suggestion that project selection criteria should be more sensitive to the impacts of actions taken now on future generations. However, sustainability as we discuss in more detail in what follows is a concept that is relevant to the project *portfolio* rather each individual project. Taking this perspective avoids counter-intuitive claims (about project desirability) arising from an overly literal translation of the sustainability concept to each individual project.

16.2. Sustainability: background

It is approaching two decades since the early shaping of the sustainability problem in the Brundtland Report. In that time, substantial progress has been made in clarifying the many controversial issues that have emerged. The concept of sustainable development itself has been defined in a number of ways. The Brundtland Report defined it as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43). Economists have tended to reinterpret this as a requirement to follow a development path where human welfare or well-being (per capita) does not decline over time (see, for example, Pezzey, 1989). Achieving sustainability, in turn, has been equated with propositions regarding how an economy should manage its wealth over time. Guiding principles in this respect include that of *weak sustainability* which emphasises changes to the real value of wealth in the aggregate and *strong sustainability* which (typically) also emphasises the conservation of *critical* natural capital, *i.e.* critically important resources for which there are essentially no substitutes. While this terminology arguably has been rather unhelpful in deflecting

attention from complementarities between the two perspectives, as it been dominant in much of the sustainability discourse over the past 10 to 15 years, we continue to use it here. Hence, in what follows, we consider each of these conditions for sustainability and their implications for CBA in turn.

16.3. Weak sustainability and CBA

For *weak sustainability* (WS) any one form of asset or capital can be run down provided "proceeds" are reinvested in other forms of asset or capital. Put another way, it is the "overall" portfolio of wealth that is bequeathed to the future that matters (*e.g.* Solow, 1986). This, in turn, is based on a rule of thumb known as the Hartwick rule (or sometimes the Hartwick-Solow rule) (Hartwick, 1977; Solow, 1974). Following this rule requires that the change in the (real) value of total wealth should not be negative in the aggregate. A good illustration of the theory of WS is provided by the literature on green national accounts. This work arises from a concern that economic indicators, such as Gross National Product (*GNP*), do not reflect the depletion and degradation of the environment and so may lead to incorrect development decisions, in much the same way that cost-benefit analyses that do not include the values people place on the environment may yield poor investment decisions.

Before proceeding to consider the implications of WS for cost-benefit analysis, some basic results from this theoretical work are briefly discussed below. This literature builds on important contributions by Weitzman (1976), Hartwick (1990) and Mäler (1991). The focus in most contributions is on accounting for the value of changes in total wealth in national income. National income is typically defined along the (optimal) path of a simple economy with stocks of goods (including natural assets used in production) and bads (including environmental liabilities, *i.e.* degradation of environmental stocks such as clean air, that negatively affect utility or well-being). A general expression for a (net) national income aggregate or green Net National Product (*gNNP*) is:

$$gNNP = C + \sum p_i \dot{X}_i = C + S_G \qquad [16.1]$$

Equation [16.1] states that *gNNP* is equivalent to consumption (*C*) plus the sum of net changes in assets ($\dot{X}_i$) each valued at its shadow price (p_i). Alternatively, this can be written as consumption plus adjusted net or genuine saving (S_G): that is, $\sum p_i \dot{X}_i = S_G$ where the changes in assets might refer to *net* investments in produced, human and natural capital.

An interpretation of *gNNP* is that it measures extended Hicksian income: that is, the maximum amount of produced output that could be consumed at a point in time while leaving wealth (instantaneously) constant (Pemberton and Ulph, 2001). Given an interpretation of (weak) sustainability that the change in the (real) value of total wealth should not be negative in the aggregate, this definition of income suggests that our focus should be on the genuine saving or S_G component of the expression for *gNNP* above. The reason for this is that S_G tells us about the (net) change in total wealth: *i.e.* it can be shown that,

$$\dot{W} = 0 \text{ if } S_G = 0 \qquad [16.2]$$

That is, the change in total wealth ($\dot{W}$) is zero if genuine saving is zero (Dasgupta and Mäler, 2000). More specifically, the key finding in this literature is that a point measure of $S_{G_t} < 0$ means that a development path is unsustainable (Hamilton and Clemens, 1999).

Negative genuine saving implies that the level of well-being over some interval of time in the future must be less than current well-being – development is not sustained.[1]

Interestingly, the proposition that negative genuine saving is unsustainable holds for (characterisations of) non-optimal development paths (Dasgupta and Mäler, 2000) and other extensions such as exogenous technological change (Weitzman and Löfgren, 1997). In addition, Hamilton and Hartwick (2005) and Hamilton and Withagen (2004) show that if S_G is persistently greater than zero – arguably a sensible policy target in a risky world – then not only is wealth (the present value of well-being) increasing but development can, in certain circumstances, also be said to be sustained.[2] The key conclusion, then, is that (persistent) *negative* genuine savings is a sure sign of unsustainability, *i.e.* of declining aggregate wealth. This is consistent with more popular notions of "not eating into one's capital" or "not selling the family silver". Persistent *positive* genuine savings is fairly indicative of sustainability, although the conclusion in this respect is less certain than for negative genuine savings.

An interesting recent development in the literature is proposed by Hamilton (2002) in response to the question as to how (weak) sustainability should be measured when population is growing. That is, S_G measures only the change in total wealth whereas, in much of the developing world, the reality is that population is growing at relatively rapid rates. In such circumstances, the net change in total wealth per capita is a better measure of sustainability (than the genuine savings rate). This can be written as follows:

$$\frac{d}{dt}\left(\frac{W}{N}\right)=\frac{\dot{W}}{N}-\frac{gW}{N} \qquad [16.3]$$

where W is total wealth, *N* is total population and *g* is the population growth rate. Hence, the net change in total wealth per capita, *d/dt*(W/N), is equal to change in total wealth (*i.e.* $\dot{W}$ or S_G) divided by total population (*N*) minus the product of total wealth per capita (W/N) and the population growth rate (*g*). Hamilton (2002) refers to this latter component of the (right-hand side of the) above expression as a "wealth-diluting" term, which represents the sharing of total wealth with the extra people implied by a country's growth in population. Clearly, for a population growth rate that is strongly positive then *d/dt*(W/N) could provide a very different signal to policy-makers about sustainability prospects than the "traditional" genuine savings rate. Indeed, Box 16.1 below provides an illustration of this for six countries.

How does CBA relate to this particular explanation of the sustainable development? At least five issues seem relevant here:

First, public projects (almost) invariably have characteristics of investments; that is, expenditures incurred early on in the project's lifetime to finance provision of a stream of benefits in the future. For example, projects might increase the supply of physical infrastructure or augment the stock of human capital via additional spending on say education and primary health-care. Thus, to the extent that a project entails the (net) accumulation of produced assets or human assets then, other things being equal, it contributes to sustainability. In other words, discussions about sustainable development should not ignore these desirable wealth-increasing properties of many projects. Of course, to the extent that projects give rise to environmental liabilities or deplete resource stocks then this loss of natural assets decreases, other things being equal, sustainability. However, as previously discussed, the net effect is signalled by aggregate indicators such as genuine saving or the net change in per capita net wealth.

Box 16.1. **Changes in wealth per capita**

The main source of year-on-year cross-country information about genuine savings is *e.g.* World Bank (2003). The World Bank typically defines genuine savings, for a nation, as gross saving *plus* education expenditures *minus* consumption of fixed (produced) capital *minus* depletion of mineral, energy and forest (timber) resources *minus* carbon dioxide damage. While the net or genuine saving rate provides useful information about how much total wealth is, on balance, being accumulated, where population is growing (or declining), the net change in (real) wealth per capita is a better measure of sustainability. Recently, Hamilton (2002) has provided empirical estimates of the change in wealth per capita (including natural resources) across a range of countries.*

Table 16.1. **Change in wealth per capita, selected countries, 1999**

	S_G/N	Population growth	W/N	Percentage change in wealth per capita
	USD	%	USD	%
US	3 597	1.2	86 255	3.0
Germany	2 203	0.0	79 761	2.7
Malaysia	827	2.4	19 200	1.9
Indonesia	–46	1.6	4 148	–2/7
Pakistan	10	2.4	2 258	–2.0
Colombia	111	1.8	9 265	–0.6

Source: Hamilton (2002).

Table 16.1 reports some of Hamilton's findings. For example, in Germany, population growth is about zero and hence the change in wealth per capita is simply equal to $\dot{W}/N$ or S_G/N. In the US, despite a relatively high percentage rate of population growth in developed country terms (mostly explained by net migration to the US), the change in wealth per capita is positive. This is also the case in Malaysia despite a percentage rate of growth of population of around 2.4%. In Indonesia, however, the wealth per capita reducing impact of a negative value of S_G/N is exacerbated by growth in population. The two remaining cases of Pakistan and Colombia are interesting in that a positive S_G/N (although somewhat marginal in the case of Pakistan) is insufficient to offset the impact on wealth per capita of an increasing population. Thus, in Pakistan and Colombia the change in wealth per capita is negative, although both of these countries had avoided negative genuine saving. In such cases, Hamilton (2002) shows that it is relatively straightforward to then calculate the savings effort that would have been consistent with a constant (real) value of wealth per capita.

* See World Bank (1997) for estimates of cross-country total wealth (including natural wealth).

To return to the example of mining cited in the introduction to this chapter, by definition, an investment in a mine that enables the extraction of a valuable but finite deposit of some natural resource is financing an unsustainable activity. That is, mining can continue only up to point that the resource is exhausted (either physically or economically). Whether there are broader implications for sustainability is another matter. Much depends on whether or not the proceeds from mining the resource are invested in an alternative (productive) asset. If the proceeds of mining are ploughed back into new and productive projects then development can be sustained.[3] From a cost-benefit perspective,

a related question is whether relevant shadow prices need to be adjusted for the fact that commercial natural resources used up today are not available for future use? In economic language, there is a "user cost" associated with the depletion of such resources. Assuming that impacts of resource scarcity are priced properly in markets, then they need no further adjustment. That is, the "user cost" will be reflected in the resource's market price.[4]

Second, while the literature on WS has been effective in emphasising the importance of raising savings rates as one element of how policy can realise concern for future generations, less attention has been given to the productivity of investments. Clearly, this latter issue falls squarely within the domain of CBA. Not only can projects, selected by cost-benefit appraisals, increase net wealth but also can further contribute to sustaining development by ensuring that savings are put to the most productive use.

Third, discussions about WS are inherently about whether an economy is saving enough for the future. In other words, there is a premise that say, a nation's savings effort might be insufficient to sustain levels of consumption or well-being over the development path. As Box 16.1 illustrates, emerging data also seem to bear out this prediction at least for certain countries. For such countries, projects – on balance – lead to wealth being liquidated. Put this way, there is an analogy with discussions about the social value of investment (*vis-à-vis* consumption) in some of the seminal contributions on shadow pricing (*e.g.* Little and Mirrlees, 1974; Squire and van der Tak, 1975). In countries where savings rates are "low", it was argued that a project that results in greater amounts of investment should get more credit (in a cost-benefit test) than a project that generates additional consumption. The rationale here was that fostering higher economic growth rates is a relative priority particularly in developing countries and raising saving and investment rates aids this goal, at least over the short- to medium-term. If so, then postponing consumption has an additional pay-off that is not reflected in the observed data. An analogous argument could be made in the context of sustainable development. However, in this case, the rationale is the proposition that *net* saving rates are too low to sustain development. If ensuring that consumption and well-being does not decline over time is a priority for public policy then this suggests that any project that raises the (net) savings rate, perhaps by investing in some asset or generating funds to be reinvested, might be assigned a premium to reflect this additional social value.

Fourth, although this approach to sustainable development is largely concerned with greening national accounts, the theoretical framework underpinning WS also gives rise to cost-benefit rules. An example is illustrated in Box 16.2. This describes a cost-benefit test of the desirability of switching land-use from standing forest to farmland. The link to sustainability, in this instance, is that land is an asset that has a distinct (social) value depending on the use to which it is put. In theory, for a country with abundant tropical forest resources it might be expected that initially there are net benefits to converting land but that in the longer term, (costless) deforestation will occur up to the point where the value of land (*i.e.* the marginal hectare) under these two competing uses is equal. In the real world, however, it would be expected that a variety of policy distortions and market imperfections can easily lead to *excess* deforestation, where "excess" can be interpreted as deforestation yielding a decline in the social value of the land asset. In other words, a cost-benefit test of the land-clearing decision would indicate that the costs of deforestation outweigh the benefits.

Box 16.2. **Sustainability and cost benefit analysis of tropical deforestation**

For many forest resources, such as tropical forests, the valuation of depletion raises an interesting challenge. The issue is essentially one of land use, with standing forests being one use among many for a particular land area. This suggests, as in Hartwick (1992, 1993), that the correct way to value deforestation is to measure the change in land value (which should represent the present value of the net returns under the chosen land use). A recent paper by Hamilton and Atkinson (2006) has provided an empirical application of this notion to deforestation in the Peruvian Amazon. While this paper focuses on the better measurement of income and wealth, in a green national accounting framework, it is also suited to evaluating whether the switch of land-use from forest to agriculture is actually wealth increasing (or "sustainable").

While Hamilton and Atkinson (2006) investigate how Peru might green its national accounts for current "excess" deforestation, arising from slash-and-burn farming, this is in essence also a cost-benefit exercise. Focusing on a broad range of costs and benefits of deforestation, the net costs of "excess" deforestation is defined as the sum of the (present) values of sustainable timber harvest and the value of the carbon sequestered by that natural growth, local and global willingness to pay (WTP) for conservation minus agricultural returns on deforested land. Using a range of market and non-market data, reflecting these changes, the authors' results are summarised in Table 16.2. These data assume that slash-and-burn farming is replaced by pasture, a social discount rate of 5% and a 20-year period for the calculation of present values. This indicates that excess deforestation is USD 1286/hectare (ha) in the year 1995. Regarding the components of excess deforestation, it is evident that the sum of (present values of) local and global WTP (where the latter is made up of non-use value) – *i.e.* USD 1015/ha -is only a little in excess of the (present) value of agricultural returns. In other words, the estimated value of excess deforestation in the table is sensitive to the estimate of the timber and carbon value of the (foregone) sustainable harvest in that it is these values that "tip" the balance such that the switch from forest to slash-and-burn agriculture can be characterised as, other things being equal, wealth-decreasing.

Regarding the bigger picture, the authors show that the effect of accounting for (net) changes in wealth that arise when forestland is cleared for slash-and-burn farming is to reduce the estimated genuine savings rate for Peru. Despite this, however, this adjusted saving rate remains strongly positive in the study year. Of course, the genuine saving calculation is an estimate of *total* saving effort, whereas the Peruvian population is growing at a rate of 1.7% per year. Performing the savings analysis in per capita terms requires, first, calculating genuine saving per capita, roughly USD 58 (for a population of 25.6 million). Then a "wealth-diluting" term, representing the sharing of total wealth with this extra 1.7% of the population in 1995, must be subtracted – this can be calculated to be about USD 131 in 1999 using the figures in Hamilton (2002). Atkinson *et al.* argue that this indicates that genuine saving per person in Peru is probably not robust, at USD 58, and that the change in wealth per capita is quite likely negative.

Table 16.2. **Value of excess derorestration, 1995**

	Components of excess deforestation (USD current)
+ Local willingness to pay for conservation	868
+ Global willingness to pay for conservation	147
+ Value of sustainable timber harvest	858
+ Value of carbon stored in sustainable timber harvest	310
? Agricultural returns	897
= Value of excess deforestation	1 286

Notes: Data refer to present values (PV); assumed social discount rate equals 5%; lifetime for PV calculations is 20 years.

Box 16.2. **Sustainability and cost benefit analysis of tropical deforestation** *(cont.)*

A number of points should be made in evaluating these findings. There is considerable uncertainty regarding the data needed to calculate these terms and, for example, the appropriate magnitude of discount rates. This gives rise to potentially wide ranges of values for much of the data (but not reflected in Table 16.2). With respect to policy implications, in this application, local forest clearance decisions reduce welfare in other countries (via loss of non-use value and a [net] contribution to climate change). In other words, the optimal mix of forest and agricultural land is different to that which currently prevails given that farmers, for some reason, cannot capture the value of conservation benefits. In reality, attempts to reduce excess deforestation will have to translate these values into transfers that farmers in Peru can appropriate. Such mechanisms, in essence, have been put into effect by the Global Environment Facility (GEF) and endorsed in international environmental agreements such as the Convention for Biodiversity.

Fifth, while project sustainability is often interpreted as depending on the achievement of the projected or forecast net benefit or rate of return,[5] the meaning of sustainable development prompts a concern about the relationship between the project intervention and its effects on the various asset bases. Projects may secure an acceptable rate of return but may not contribute as much as they might to the goal of sustainable development just as projects may also fail to secure the highest gains for the poorest people in the current generation.

The contribution of a project to sustainable development could be gauged by way of an "*asset check*", to examine what the stocks of assets are before the project intervention and what they are likely to be after the intervention. In other words, the project could be appraised in the context of the overall asset stock and the extent to which it is depreciating or appreciating independently of the project. In contrast to a standard benefit-cost appraisal, this would force the focus to be more specifically on capital assets. This approach also raises the issue of whether any of the asset stocks are "critical" (the strong sustainability approach).

An asset check procedure could separately address total assets, specific critical assets, technological effects on asset productivity, the background rate of population growth and asset resilience, for example. In each case an assessment of the "baseline" value of the asset stock would be required, *i.e.* the size of the asset stock at any point of time, allowing for any levels of asset depreciation taking place independently of the project. Next the effects of the project on these assets could be estimated.

16.4. Strong sustainability and CBA

Important as it might be, discussions about sustainable development in the context of project appraisal seldom focus primarily on the desirable wealth increasing properties of these projects. Rather the focus of these contributions more usually has been on what has been termed strong sustainability (SS, or strong sustainable development).[6]

Advocates of SS as a guiding principle argue that it is the physical protection of absolute levels of ecological goods that is a prerequisite for sustainability. If individual preferences cannot be counted on to fully reflect this importance, there is a paternal role for decision-makers in providing this protection. Reasons for this include the complexity of ecosystems and the view that the diminished capacity of the environment to provide

functions, such as waste absorption and ecological system maintenance, cannot be replaced or substituted (Norton and Toman, 1997). Furthermore, it is argued that natural assets are characterised by important thresholds, that if exceeded lead to large-scale and irreversible ecological losses with possibly dramatically negative impacts on human well-being. There are several variants on this proposition. For example, very few supporters of SS (explicitly) argue that all natural assets must be separately conserved. More usually it is argued that there is a subset of *critical* natural assets, which are both crucial for human welfare and have no substitutes: therefore, it follows that such assets cannot be simply traded off for other forms of wealth and must be managed according to more case-specific criteria (Pearce *et al.* 1989).

Defining more precisely which natural assets are critical and which are not is clearly a fundamental element in ensuring that this approach is useful for policy-making and appraisals. Before we turn to this issue in more detail, we firstly marshal the broad implications of SS. Focusing on the essential idea that a given physical amount of a resource must be preserved intact in order that it may continue to provide critical services, a two-tier approach to sustainability is suggested. For example, Farmer and Randall (1998) outline the implications of the (long-established) concept of a "safe minimum standard" (SMS) whereby policy-makers follow standard cost-benefit rules unless there is a compelling reason not to; *e.g.* to conserve a critical natural asset. However, this SMS conservation rule can itself be overridden if its costs are "intolerable".

Pearce *et al.* (1996) provide an illustration of how this two-tier approach might operate in the case of a tropical rainforest. In this example, preserving some quantity of the forest is assumed to be critical for the long-term well-being of humanity. The effect of this preservation is to reduce the amount of forest that can be considered to be an economic resource (*i.e.* it reduces the quantity of harvest or clearance that can be carried out from the non-conserved stock). The key indicators for a country with tropical forest operating under this regime will be twofold: are stocks of this critical natural asset declining? and are genuine savings rates (*i.e.* savings net of the change in the non-conserved resource stock) negative? A positive answer to either of these questions would be an indication of unsustainability.

If analysts were able to monetise critical natural assets, then the policy implications of the SS perspective, in cost-benefit terms, become even plainer. One means of capturing the notion of the value of a critical amount of a resource or natural asset is by assuming that,

$$p_i \rightarrow \infty \text{ as } X_i \rightarrow \overline{X}_i^+$$

where, $\overline{X}_i^+$ is the critical amount of the natural asset – *i.e.*, as the resource declines to the critical amount, arbitrarily large losses in welfare are associated with depletion of a marginal unit (Hamilton and Atkinson, 2006). This could correspond to a physical process, such as rapid deterioration in forest quality and diversity once a critical threshold has been breached (Pearce *et al.* 1996). Approaching this physical threshold would show up as a correspondingly large loss in value of the critical natural asset. Hence, if preferences for critical resources are taken into account, then the optimal or most socially desirable policy is to be strongly sustainable (*i.e.* set limits on resource depletion so as to avoid the prospect of rapidly increasing losses in welfare). Yet, while this approach can handle strong sustainability in principle, in practice it requires good measures of willingness to pay for a critical resource and sufficient scientific and economic information (concerning the

relative importance of the loss of the resource) for preferences to reflect the appropriate trade-offs that would underpin this willingness to pay estimate.

With regards to project appraisal, a number of studies, beginning with Barbier *et al.* (1990), have sought to examine the specific implications of concern about strong sustainability for CBA. While these are largely conceptual contributions, there is also growing practical interest in the application of, for example, resource compensation in assessing real world examples of damage to natural and environmental resources. The basic approach taken, in theory and in practice, is to recognise that strong sustainability is a concept that is most relevant to the management of a *portfolio* of projects. That is, for example, imposing a constraint on project selection that each individual project does not damage the environment is arguably too stringent (in the sense that very few projects would presumably yield net benefits yet not damage the environment at all).

More accommodating proposals for selecting projects subject to a (strong) sustainability constraint usually advocate that the *net effect* on the environment of projects in a portfolio should be, at least, zero. Leaving aside, for the moment, the issue of what it is precisely that projects should (on balance) seek to conserve, we examine in more detail the broad principles of the approaches, for example, in Barbier *et al.* (1990) and later in Pires (1998) for subjecting a cost-benefit test to a (strong) sustainability constraint.

Each project *i* is associated with environmental costs, *E*. How these costs are to be measured is largely ambiguous. While monetary valuation would seem to be one candidate method, if shadow prices could be correctly estimated then it is unclear why sustainability concerns simply could not be built into standard net benefit estimates. The apparent need for additional sustainability constraints implicitly suggests that certain environmental costs are not measurable in this way. This point aside, the basic issue is that some projects "on offer" will lead to depletion or degradation of natural or environmental resource stocks: *i.e.* $E_i > 0$. Other projects "on offer" will lead to resource stocks being restored or augmented: *i.e.* $E_i < 0$. Two general constrained decision-rules have been put forward as capturing concern for strong sustainability within a cost-benefit setting.

First, a stringently strong constraint, for cost-benefit tests, might be imposed that in choosing projects that maximise net benefits, the *aggregate* environmental costs, *i.e.* $\sum_{i=1}^{n} E_{it} t$, of all projects chosen for inclusion in the portfolio should be zero in each time period, *t* (which, for example, might correspond to a year). That is,

$$\sum_{i=1}^{n} E_{it} \leq 0 \qquad \forall t \qquad [16.4]$$

The matrix in Figure 16.1 describes project selection criteria in more detail. Either of four cases might arise for any given project *i* for different possible permutations of net benefits (*NB*) and environmental costs (*E*), both of which may be either positive or negative. Decision-making in case where $NB_i > 0$ and $E_i < 0$ is relatively straightforward; that is, the project should be unambiguously accepted. Similarly unproblematic are cases where $NB_i < 0$ and $E_i > 0$ as such projects should be unambiguously rejected. However, deciding about the remaining cases necessitates additional judgements about say whether environmental costs ($E_i > 0$) for the current project under consideration can be compensated by environmental gains provided by another project within the portfolio ($E_j < 0$). However, the portfolio constraint that should be observed is that environmental costs, across all projects in the portfolio, should be at least zero. If the same is required of total net benefits

then what this means is that the portfolio at least breaks-even on the basis of non-environmental benefits and costs as well as maintaining the environmental *status quo*.

Figure 16.1. **Project selection and strong sustainability**

	$E_i < 0$	$E_i > 0$
$NB_i > 0$	Accept	?
$NB_i < 0$	?	Reject

Note: Adapted from Bateman *et al.* (2002).

Second, a more flexible strong constraint might be imposed that the net environmental effect of all projects in a portfolio should be zero over some longer time horizon, T (where $T > t$). That is,

$$\sum_{t=1}^{T}\sum_{i=1}^{n} E_{it} \leq 0 \qquad [16.5]$$

Put another way, the constraint here is that it is the present value of environmental costs that should be zero over this time horizon. Hence, this is less stringent (than previously) in that it permits a greater degree of temporal flexibility in meeting the specified sustainability constraint. Arguably, environmental costs in equation [16.5] should also be discounted – *e.g.* weighted by $[1/(1 + s)^t]$ where s is the social discount rate. This would simply reflect the fact that a project that restores environmental quality at some point in the future is less valuable than a project which restores environmental quality now.

Quite how long this planning horizon should be is an interesting question although most contributions have offered little practical guidance on this matter. On the one hand, environmentally improving projects are primarily intended as compensation for future generations, which might suggest no requirement for haste in implementing these compensating projects. On the other hand, if the current generation receives substantial amenity from at least some of these resources, then this might suggest a greater degree of urgency.

Observing the sustainability constraint in the expression immediately above requires that any environmental loss is compensated by an environmental gain of equal (present) value. What this amounts to is a requirement that the value of a natural asset is eventually kept intact, a basic tenet of (strong) sustainability. However, in the interval between damage and compensation occurring there is some loss of well-being as the natural asset, during that time, does not provide the same level of environmental services. Of course, asking how far all this matters in practical terms is a valid question. Nevertheless, it is far from a purely theoretical issue. Sustainability is fundamentally about ensuring (at least) a constancy of a development path. Whether permitting actions, which result in a development path where there is a drop in well-being at some early stage followed by an offsetting jump in well-being at some later point, is consistent with this emphasis is likely to hinge on issues about how steep the initial drop is and how long before the corresponding gain is realised. As ever, the issue is the correct balance. That is, defining T to be too short-term brings us back to the stringently strong constraint defined above. Interestingly, some of these issues are illustrated in the context of climate change policy as Box 16.3 shows.

Box 16.3. **Climate change and shadow projects**

While few, if any, would argue that the Kyoto Protocol will contribute to strong sustainable development, some of its provisions, which mandate legally binding reductions in greenhouse gas emissions (GHGs) across relatively high-income countries and economies in transition, illustrate the ideas introduced by those who have examined strong sustainability in the context of project appraisal. For example, countries have to achieve GHG targets, *on average*, over a 5-year period (2008-12). That is, it allows any country to say undershoot its target in any one year as long as this is made-up by a corresponding overshoot in some other period. Of course, permitting this flexibility is simply the exercise of commonsense in assisting countries meet a costly objective. However, it also illustrates how the broad idea of shadow projects might be conceived in practice. Moreover, the Kyoto Protocol also allows parties to "bank" (*i.e.* receive credit in the future for) any GHG reductions resulting from over-compliance within the first control period or "trades" under the Clean Development Mechanism (CDM). Interestingly, however, it does not allow countries to "borrow" future emission reductions. The case of the CDM is also interesting in that it implies compensating for emissions of carbon dioxide arising from one "project" (*e.g.* coal-fired electricity generation), in one country, by the financing of a project that sequesters (more than off-setting) reductions in atmospheric carbon dioxide in another country (*e.g.* "clean" energy or planting trees).

Both of the methods for integrating SS criteria into a cost-benefit test broadly correspond to what has become known as the shadow and compensating projects approach. For example, projects that cause environmental damage are "covered off" by projects that result in environmental improvements. Quite what this means in practice is another matter. The timing of compensations is just one issue. Another is that natural assets are heterogeneous and so questions arise as to whether this term – "net effect" – refers to a specific natural asset (*e.g.* wetlands) or natural assets in general. In principle, requiring that projects in a portfolio leave the overall (present) value of natural assets intact, raises the prospect of allowing a project which damage wetlands as long as these are accompanied by a compensating project which seeks to improve say urban air quality.

Typically, however, most of the discussion about shadow projects has centred on replacing "like-with-like": *e.g.* a wetland for a wetland. A number of analytical dilemmas still arise. Depending, for example, where original and compensating resources are located, the winners and losers in each case could be either wholly or very different. Other issues include the measurement of what is lost and what is replaced. Some degree of quantification must be implied in this process. Otherwise, how can it be credibly claimed that compensation has taken place? Such issues, and others, are discussed in Box 16.4 which also outlines a somewhat different rationale for shadow projects – the "Public Trust Doctrine" – to that embodied in the "critical capital" terminology.

16.5. Summary and guidance for decision-makers

The notion of "sustainable development" has permeated significant parts of policy and public discourse about the environment. While there remains debate about it means for development to be sustainable, there is now a coherent body of academic work that has sought to understand what a sustainable development path might look like, how this path

Box 16.4. **The public trust doctrine and shadow projects**

Chapman and Hanemann (2004), in the US public policy context, provide a distinct variant on the justification for shadow projects, which they term the "Public Trust Doctrine". This approach does not appeal *directly* to contested ethical or scientific imperatives (as typically, accounts about strong sustainability do). Rather it draws on the authority of legislative or constitutional requirements that (certain specified) natural and environmental resources are held in trust for the public (now and in the future). Put another way, this view holds that there is a legal basis for stating that particular resources be replaced "like-for-like". Interestingly, actions entailing resource compensation – implied by this Doctrine – is potentially to become a lively issue in the European context as it is part of the proposed EU Directive on Liability.

In the US, this Doctrine apparently has a relatively long lineage dating back, at least, to the late 19th century. At the national or federal level, it assigns broad power to the government to protect certain resources and, more recently, has been extended to the public interest in the natural environment. Additionally, at the state level it has formed the basis for natural resource damage assessment. One high profile and recent impetus to this Doctrine was the creation of the Superfund to finance the remedial cleanup of existing hazardous waste sites. This established a liability to pay damages for injury, destruction or loss of natural resources in addition to the costs of cleanup, remediation and other response costs.

More generally, the Public Trust Doctrine motivates shadow projects in requiring that restoration the natural asset in question acts as compensation for natural resource damage. Put another way, if the resource is, in effect, held in trust for future generations then liquidating that asset – even with financial (or some other) recompense – will not suffice. Rather the asset itself must be restored and so it is the cost of restoration that forms the basis for this claim especially "… when replacement resources are of similar type, quality and comparable value" (NOAA Guidelines cited in Chapman and Hanemann, 2004). Resource compensation might take two forms. First, "value-to-value" – a given resource is replaced elsewhere by the similar resource of equivalent value. Second, "service-to-service" – a given resource is replaced elsewhere by the similar resource, which provides equivalent (non-monetised) services. An example of the former, outlined by Chapman and Hanemann is Lavaca Bay, a Marine Superfund site in south Texas. This is a site which has suffered injury to its ecological resources (salt marsh and fish and migratory birds). Restoration involved developing the area of acreage of habitat restoration required and damages owing were based on cost of implementing the "appropriate" restoration actions.

A number of issues arise from the application of the restoration cost approach to real world examples. Wetland restoration provides a prominent illustration. "Wetland banking" in the US allows a party to substantially alter a wetland if they purchase credit earned by another party for protection or enhancement of another wetland. These credits are then traded through a "wetland bank". The overall requirement is that there is no net loss in wetlands. In other words, this is a form of resource compensation or institution for facilitating the "purchase" of shadow projects. While this seems an inventive means of conserving wetlands, in the aggregate, it is not surprisingly associated a number of problems. First, data requirements can be large and burdensome (although this is hardly a conclusion unique to this type of work). Second, the created ecosystem can fail in the sense of not providing an adequate substitute habitat or some other ecological function. Third, inevitably there is the problem of whether "like" being replaced with "like". For example, a cross-habitat assumption of equal per unit value (*e.g.* a hectare) may be invalid as it is entirely possible that the "created" ecosystem is likely to be less valuable than a degraded natural ecosystem. Proposals to deal with this latter problem include that of "two-for-one": *i.e.* replacing one lost wetland with two new ones.

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can be achieved and how progress towards it might be measured. While it is hardly surprising that these efforts have not generated a consensus, there has been considerable progress in understanding where agreement and disagreement is and why this arises.

Much of this work considers the pursuit of sustainable development to be an aggregate or macroeconomic goal. By-and-large cost-benefit analysts have not sought actively to engage with this broader debate except insofar as it relates to factors affecting a project's forecast net benefit or rate of return. However, it should be noted that recent developments discussed elsewhere in this volume – most notably on valuing environmental impacts and discounting costs and benefits – are relevant to this issue. In this chapter, we have discussed a number of additional speculations about how cost-benefit appraisals can be extended to take account of recent concerns about sustainable development.

According to one perspective there is an obvious role for appraising projects in the light of these concerns. This notion of strong sustainability starts from the assertion that certain natural assets are so important or critical (for future, and perhaps current, generations) so as to warrant protection at current or above some other target level. If individual preferences cannot be counted on to fully reflect this importance, there is a paternal role for decision-makers in providing this protection. With regards to the relevance of this approach to cost-benefit appraisals, a handful of contributions have suggested that sustainability is applicable to the management of a *portfolio* of projects. This has resulted in the idea of a shadow or compensating project. For example, this could be interpreted as meaning that projects that cause environmental damage are "covered off" by projects that result in environmental improvements. The overall consequence is that projects in the portfolio, on balance, maintain the environmental status quo. Practical applications of this approach include wetland loss and compensating restoration in the US.

There remain a number of outstanding questions about the broader applicability of this approach. Specifically, the demarcation between those assets which can be thought of as critical and those which are not is, in practice, far from clear. Indeed, any practitioner familiar with this on-going debate may be forgiven for developing a sinking feeling at the prospect of having to translate these discussions in practical lessons for appraising projects, for there are arguably few clear signs that any dramatic progress has been made in this regard. This is despite the fact that the "critical capital" terminology (and sweeping claims about its policy implications) is now commonplace in the literature.

Some have sought to characterise "criticality" according to ecological criteria while others have drawn on political or constitutional precedents (*e.g.* the Public Trust Doctrine). In the case of the former, for example, proponents have been tempted into defining critical assets very broadly perhaps to include most types of natural assets. Yet, the evidence on which this broad sweep relies is dependent on weighting decision-making heavily in favour of precaution. This raises important issues. On the one hand, there is a benefit to avoiding untoward and irreversible damage to (possibly) critical resources. On the other hand, there are likely to be significant costs to applying the shadow projects approach as widely as this perspective would imply. Interestingly, while specific real world examples can be found that approximate the notion of a shadow project there is arguably little evidence of wider enthusiasm for this particular approach.

There are further ways of viewing the problem of sustainable development. Whether these alternatives – usually characterised under the heading "weak sustainability" – are complementary or rivals has been a subject of debate. This debate would largely dissolve if

it could be determined which assets were critical. As this latter issue is itself a considerable source of uncertainty, as we have discussed, the debate continues. However, the so-called "weak" approach to sustainable development is useful for a number of reasons. While it has primarily be viewed as a guide to constructing green national accounts (*i.e.* better measures of income, saving and wealth), the focus on assets and asset management has a counterpart in thinking about project appraisal. For example, this might emphasise the need for an "asset check". That is, what the stocks of assets are before the project intervention and what they are likely to be after the intervention? It might also add another reason for the tradition in cost-benefit analysis of giving greater weight to projects which generate economic resources for saving and investment in economies where it is reckoned that too little net wealth (per capita) is being passed on to future generations.

Notes

1. However, it is important to note that a point measure of positive SG, *i.e.* $S_{G_t} > 0$, does not necessarily mean that a development path is sustainable (Asheim, 1994; Pezzey and Withagen, 1998). In other words, S_G is strictly speaking a one-sided indicator of sustainability.
2. Specifically, this requires that the growth rate in genuine saving does not exceed the interest rate.
3. For many countries, in practice, it appears that the prudent path of saving the proceeds of resource depletion has been difficult to achieve. Indeed, a number of contributions have sought to identify explanatory factors that account for the inability of resource-rich economies to transform this natural good fortune into saving (see, for example, Atkinson and Hamilton, 2003).
4. Johansson (1993) notes that where extraction (or harvest) is not optimal – in the sense of the gain from using up a unit now exactly matches the loss from not having that unit in the future – that there is an additional imputation to reflect the mismatch between current gains and future losses.
5. For example, the World Bank's Operations Evaluation Department refers to the resilience to risk of net benefits flows over time, where these risks are broadly construed to include financial risk, institutional risks and so on (see, for example, Belli *et al.,* 1998).
6. Some contributions refer to "environmental sustainability" or "environmentally sustainable development". However, the definition of these terms accords with the definition of strong sustainability and strong sustainable development used in this chapter.

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