Operationalising Strong Sustainability: Definitions, Methodologies and Outcomes

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ABSTRACT

While acknowledging the absence of a single definition or theory of sustainability, this paper argues that a discussion of sustainability which refers only to definitions is pointless without an understanding of how the definitions are operationalised. In this context, the paper considers the operationalisation of strong sustainability.

The definitions and operationalisation of strong sustainability most closely associated with (i) neoclassical environmental economics and (ii) ecological economics are discussed and compared. This analysis raises questions about the extent to which ecological economics has been able to influence real-world decisions and policy. The paper ends by considering whether the economic and political power structure taken as given by ecological economics is compatible with its policy perspective.

KEYWORDS

Strong sustainability, ecological economics, critical natural capital

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1. INTRODUCTION

Given the absence of a single, unified definition or theory of sustainability, this paper argues that a discussion of sustainability which refers only to definitions is pointless without an understanding of how these definitions are operationalised. The operationalisation of the concept of sustainability in terms of policy prescriptions is more problematic than reaching a consensus on its definition, since there exist different approaches to environmental management, each with different assumptions regarding human nature, nature itself, society at large, and their interactions. In the context of ongoing discussion of the nature of ecological economics and its relationship to neoclassical environmental economics,[1] this paper analyses the different ways in which the concept of strong sustainability is operationalised within the two approaches.[2] The analysis provides insights into both environmental economics and ecological economics. It also raises questions about the economic and political conditions necessary for the policy perspective that emerges from ecological economics to be implemented.

The formulation of strong sustainability most closely associated with the environmental economics literature (found for example in the *Blueprint* series by Pearce et al.) is maintenance of the stock of natural capital with additional critical natural capital constraints. The formulation that has appeared in much ecological economics literature refers to preserving physical stocks of critical natural capital. Overall, one might have the impression that the first formulation offers a tighter or more stringent rule than the second because, while both speak of critical natural capital, the first rule also calls for the maintenance of the stock of aggregate natural capital.

The contention of this paper, however, is that a comparison of definitions is inadequate without attention to operationalisation. The key role of the operationalisation process is illustrated by the fact that a review of the literature indicates that, for neoclassical authors, issues relating to critical natural capital are now rarely discussed. Instead, they typically interpret strong sustainability in terms of the *economic* value of the entire natural capital stock. This shift to an almost exclusive emphasis on the overall economic value of natural capital has occurred alongside the vast amount of effort and literature devoted to developing environmental valuation techniques. Once this emphasis on the aggregate economic value of natural capital has been established as dominant, the implications of this approach are discussed in terms of three key requirements of strong sustainability that have been identified in the literature, namely, inter- and intra-generational equity and ecosystem resilience.

The approach of many within ecological economics to operationalisation and to the analysis of critical natural capital is explicitly different from that of environmental economics. This paper targets the preservation of specific forms of critical natural capital directly in physical terms, insisting on the concept of incommensurability and the necessity of non-monetary indicators. Having established this, we assess the potential of ecological economics for operationalising strong sustainability in terms of physical measures of thresholds for critical natural capital.[3]

The paper ends by identifying areas where ecological economics needs further development. This is partly motivated by questions that have been raised over the extent to which it has so far been able to influence real-world decisions and policy. We discuss the possibility that this may be due to an incompatibility between the policy perspective that emerges from ecological economics and the existing distribution of economic and political power that it largely takes as given.

2. OPERATIONALISING STRONG SUSTAINABILITY WITHIN ENVIRONMENTAL ECONOMICS

Environmental economics, as a modified version of the neoclassical paradigm, has been able to expand the horizons of neoclassical theory by accommodating environmental concerns in its analysis and has become the most developed economic theory concerning environmental problems. Particularly well known are the contributions of the London School of environmental economists, such as Pearce, Barbier and Markandya (1989, 1990) and Pearce and Turner (1990), who developed the concept of the maintenance of the natural capital stock as a condition of the strong version of sustainable development (see also Victor, 1991; Munda, 1997).

In this regard, *Blueprint for a Green Economy* (1989) by Pearce, Markandya and Barbier represents a milestone in the environmental economics and sustainable development literature. Recognising the uncertainty surrounding many of the life-supporting functions of the natural world, and the fact that these functions are often irreversible, the authors argue that constancy of the natural capital stock[4] is a rational objective since there is no real substitute for many of these life-supporting functions (Pearce et al., 1990; Barbier et al., 1990; Klaassen and Opschoor, 1991; Pearce, 1998). In their work they also acknowledge the critical importance of some specific individual components of natural capital. One of the clearest statements that reflects their position on strong sustainability is the following:

> [s]ustainable development is categorised by economic change subject to 'constancy of the natural capital stock' – the stock of environmental assets is held constant while the economy is allowed whatever social goals are deemed appropriate. Such a rule, which has its own difficulties, accommodates the main concerns of the advocates of sustainability – equity between generations, equity within a generation, economic resilience to external shocks, and uncertainty about the functions and values of natural environments in social systems (Pearce et al., 1988, p. 598).

The ways in which this recognition of the distinctiveness of natural capital have been developed and operationalised within environmental economics are now explored. The implications of this development and operationalisation are assessed in terms of the overall aim of strong sustainability and the validity of some of the additional claims that have been made for this interpretation of strong sustainability.

2.1 The Constancy of the Natural Capital Stock in Environmental Economics

Given that constancy of the natural capital stock is mentioned as the 'key necessary condition' (Pearce et al. 1990, p. 4) of sustainable development, the discussion then turns to what is meant by a constant stock of natural capital. Barbier et al. (1990, p. 1260) identify the constant *physical quantity* of the natural stock and the constant *economic value* of that stock as the most frequently articulated approaches.[5] Pearce et al. (1989, p. 115) note what they see as the shortcomings of measuring natural capital stock in physical terms: 'physical accounts *are* useful in answering ecological questions of interest and in linking environment to economy…However, physical accounts are limited because they lack a common unit of measurement and it is not possible to gauge their importance relative to each other and to non-environmental goods and services'. It rapidly becomes clear (Barbier et al., 1990; Pearce and Turner, 1990) that it is the constant economic value approach that underlies Pearce and Turner's constant capital rule.

The economic value approach offered is to value resources in monetary terms and then calculate the aggregate monetary value of the stock of natural resources. Pearce and Turner (1990, p. 53) state:

> [i]f this could be done, in the same way as we make estimates of the 'national wealth' – i.e. the stock of man-made capital then we could rephrase the K_N requirement in terms of a constant real value of the stock of natural assets.

Thus, it may be posited that behind the rationale of the valuation of the total stock of natural capital lies the belief that 'sustainability can be analysed in terms of a requirement to maintain the natural capital stock' in monetary terms (Pearce and Turner, 1990, p. 52).

Pearce and Turner (1990, p. 121) argue that money is chosen as the means of measurement because 'all of us express our preferences every day in terms of these units – when buying goods we indicate 'our willingness to pay' (WTP) by exchanging money for the goods'. Furthermore, in Pearce et al. (1989, p. 56), it is indicated that monetary measures are preferred because they show the *degree* of concern and, if they are large enough, this makes the case for preservation stronger. Monetisation is also said to allow for comparison between alternative uses of the resources (Pearce et al., 1989).

Barbier et al. (1990, p. 1260) explain how this necessary condition of the preservation of the natural capital stock can be made operational. In accordance with their suggestion, the concept of constant natural capital stock can be operationalised by integrating this objective at the micro-level into cost-benefit analyses:

> [s]ustainability can be introduced into CBA by setting a constraint on the depletion and degradation of the stock of natural capital…Essentially, the objective of economic efficiency is modified to mean that all projects yielding net benefits should be undertaken subject to the requirement that environmental damage (that is, natural capital depreciation) should be zero or negative.

Internalisation of the environmental costs of individual projects is seen as insufficient in general since, even if the environmental costs are internalised effectively in each project of the appraisal process, it can still be the case that 'the total environmental damage costs generated by the portfolio of *n* projects could be greater than zero' and as a result the portfolio could continue to degrade the environment (Barbier et al., 1990, p. 1260). Thus, in order to ensure strong sustainability, a non-positive net environmental damage cost across all projects and for every time period is introduced as an explicit constraint (Barbier et al., 1990, p.1265).

Turner (1993) and Pearce (1976, 1998), however, also touch upon the limitations of cost–benefit analysis in cases where some biological effects, such as an excess volume of waste residuals over the ecosystem's assimilative capacity, are present but economic externalities seem absent. Once ecological feedback mechanisms are accounted for and the consequences of exceeding thresholds have been established, it is acknowledged that cost–benefit analysis is not necessarily consistent with dynamic optima (Pearce, 1976, 1998). In such a context, it is argued, cost–benefit analysis is not necessary since physical information is considered sufficient in identifying the optimum in terms of threshold effects. The problem here is that in the vast majority of related literature (Pearce et al., 1988, 1989, 1990; Barbier et al., 1990; Pearce and Warford, 1993; Pearce and Moran, 1994; Pearce, 1998), the thresholds are never specified or stressed, with the focus instead being on the constancy of natural capital and its proper valuation.

In principle, therefore, although not normally in practice, it may be the case that a certain type of physical threshold is suggested for some critical natural capital, rather than monetary valuation. However, as van der Straaten (1999) rightly notes, the internal consistency of a theoretical framework within which there are price signals and values alongside physical magnitudes needs to be questioned. Pearce (1998, p. 43), for example, indicates that

> there may be thresholds in some cases but not in others, and the damage beyond the threshold may or may not be characterised by non-linearities…[I]t would be unwise to build a science on the basis of limited rather than general ecologi-

> cal behaviour', and continues, 'deliberately accepting levels of damage that are known to create physical changes to ecosystems may set off a dynamic feedback mechanism…if it does, then the negative consequences of a feedback effect are essentially traded off against the opportunity cost of the resources that would be needed to reduce those effects. Once the trade-off is acknowledged, then we have entered the world of valuation.

It is also argued in Pearce et al. (1994) that, although some biophysical measures do exist and are needed before any monetary valuation, it is better to evaluate environmental impacts in monetary terms wherever this is feasible and credible, since this provides one more argument for conservation. Hence, in accordance with the literature, it is possible to treat the rule of constant natural capital stock as the general rule in practice, without addressing the issue of whether or not there may exist some exceptions. The critical discussion that follows will therefore be mainly focused on this general rule.

Since the issue at the heart of the environmental economists' understanding of strong sustainability is monetising the value of environmental resources and systems, the problem inevitably reduces to the proper economic valuation of natural resources and environmental impacts. The absence of market prices for many natural resources, and therefore the need to identify observable or shadow prices, is an immediate problem in this context. However, environmental economists have not seen this as insurmountable, hence Pearce et al.'s optimism that, 'whether there is an actual market in the asset or not is not of great relevance. We can still find out what people would pay if only there were a market' (1990, p. 8).

As Jacobs (1991) points out, it is possible to make two kinds of criticism of this approach to maintaining a constant value of natural capital. First, it can be accepted that, while there may in principle be meaning to such an estimated monetary value, there are nevertheless major technical problems associated with such estimation. There exists a vast amount of literature on environmental valuation techniques, particularly concerning the ways in which contingent valuation surveys should be conducted in order to increase accuracy and avoid bias (Arrow et al., 1993; Hanemann, 1994; Diamond and Hausmann, 1994). The second line of criticism is more fundamental, arguing that the basic concept of the monetary valuation of natural resources may be questioned and that there can in principle be no meaningful monetary values for such resources (Köhn et al., 1999).

This second line of criticism is set out in the next section, reflecting our view that the problems surrounding the interpretation of strong sustainability as the maintenance of the value of the natural capital stock are more conceptual and fundamental than technical. It is then argued, in the following section, that the maintenance of a single constant monetary value of natural capital, as advocated by leading environmental economists, is inconsistent with the claims for strong sustainability that these authors make. In particular, it is argued that this approach is unlikely to realise their claims made in relation to inter-generational equity, intra-generational equity, and ecosystem resilience.

2.2 Is a Constant Economic Value of Natural Capital a Meaningful Indicator of Strong Sustainability?

The formulation of strong sustainability as constant natural capital stock is dependent on the proper valuation of aggregate natural capital. It is, therefore, essential to look at the methodology underlying the monetary valuation process. Pearce, in a number of articles, complains about the misinterpretation of the concept of economic value and insists that monetary valuation is about measuring preferences (Pearce and Turner, 1990; Pearce, 1993, 1998). He states that '[w]hat is being valued is not "the environment" or "life", but people's preferences for changes in the state of their environment, and their preferences for changes in the level of risk to their lives' (Pearce, 1993, p.13). The critique that follows is not the result of such a misunderstanding but is informed by Pearce's clarification of what is being measured.

The practical attempts of Pearce and his colleagues in the *Blueprint* series to develop policies aimed at moving toward strong sustainability are faced with three problems. First, there is the problem of incommensurability. A crucial and central question in the valuation discussion is whether or not a single common unit of measurement can adequately express environmental concerns. Some environmental features are generally accepted as being incommensurable because of the complex and inter-related attributes of the ecosystem. In relation to this discussion, Pearce (1998, p. 30), while accepting the criticism as an important one, notes that this '"uncertainty of function" … is not … a criticism peculiar to economic valuation alone, but is a weakness of all decision-making procedures' and reiterates his claim to be placing monetary values on people's preferences, not on the environment.

However, the incommensurability critique remains valid even in a context where it is accepted that valuation of preference for change rather than valuation of the ecosystem is the issue, and where values are considered to be nothing more than the articulation of people's preferences. As Vatn and Bromley (1995, p. 9) point out, 'one metric (price) is unable to capture all relevant information' about the different kinds of values assigned by an individual to the environment because of the *moral aspect* of environmental choices. Arguments for wilderness and wildlife, for example, necessarily incorporate both economic and ethical considerations and commitments, both tangible and intangible values, which mean that they should be treated separately, without assigning a single attribute to represent both (Craig, Glaaser and Kempton, 1993; Gowdy, 1997).

Pearce et al. (1989, p. 57) argue that accepting values as being commensurable and using monetary units as a measuring rod may help in the facilitation of decision-making processes: 'CBA is the only [approach] which explicitly makes the effort to compare like with like using a single measuring rod of benefits and costs, money'. However, while it is true that contingent valuation methods seem to take into account a range of environmental values, the qualitative difference between types of values is still neglected (Spash, 1999). It can be argued, therefore, that it is more appropriate to include different types of environmental values explicitly *within* the decision-making process, as proposed by Martinez-Alier (1997) and O'Neill (1997), through a process of social evaluation or deliberation, rather than focusing exclusively on valuation techniques premised on commensurability.

A second problem in relation to the valuation process is the dependence of the economic value of natural capital on the distribution of income (Martinez-Alier, 1995; Jacobs, 1991). It is universally accepted that willingness to pay is a function of income as well as preferences. Furthermore, as Boyce (1994) rightly notes, monetary valuations are also affected by inequalities of wealth and power.[6] Yet despite this, in the environmental economics literature the current income distribution is taken as given and distributional issues are either given secondary attention or are ignored (Spash, 1999; Martinez-Alier and O'Connor, 1999). This means that the use of the constancy of the monetary value of the stock of natural resources as an indicator of sustainability is misleading in a very precise way; it has no relation to the viability of the biophysical condition of the planet. It is possible for the value of natural capital, calculated on the basis of a given distribution of income, wealth and power, to fall following a change in distribution and yet for there to be no change in the underlying biophysical condition. Equally, a change in distribution may result in the maintenance of the monetary value of aggregate natural capital even though the underlying biophysical condition of the planet has deteriorated. Thus, constancy of the monetary value of the natural capital stock is clearly not an acceptable indicator of sustainability.

A third methodological problem directly affecting the economic value of the stock of natural capital is that the whole valuation process is built on the idea of rational, optimising agents who have exogenously determined preference functions (Hodgson, 1997). A fundamental assumption of the neoclassical model is that preferences are taken as given, with the cultural, educational and social processes through which they are formed abstracted from (Hodgson, 1997; O'Neill, 1997). However, a strong counter-argument has been developed from an institutional perspective suggesting that preferences need to be treated as endogenous, with their characteristics largely shaped by the context in which they are formed (Hanemann, 1994; Hodgson, 1997). Thus, Hanemann (1994) argues that respondents in contingent valuation surveys have no real *a priori* value for the environmental good in question but create one during the survey process and the value they create will be dependent on the nature of the process. If this is the case, then accepting contingent valuation, or any other hypothetical valuation technique, as a legitimate decision-making tool for environmental issues implies acceptance of an underlying model that is even less appropriate for public goods than it is for private goods (Jacobs, 1997). This isolated, private and non-changeable preference model, and the associated willingness to pay approach, appear particularly inappropriate in the case of environmental decisions where both social processes and the context within which choices are made play a major role in defining and forming those preferences (Vatn and Bromley, 1995).

We accept, of course, that in the context of market allocation the rate of depletion of resources with a zero or low price will be slowed by an increase in price. However, it is quite another matter to claim that a constant monetary value of the stock of natural capital is an adequate indicator of strong sustainability. We have identified three reasons why this claim is invalid: the problem of commensurability; the dependence of the value of natural capital on the distribution of income, wealth and power; and the path dependency of endogenous preferences. Environmental economics is inappropriate for social evaluation because its defining methodology of attempting to measure social costs and social benefits by simply aggregating each person's valuation, made in isolation, is itself inappropriate (Martinez-Alier, 1997). Estimates of the economic value of the stock of natural capital derived from aggregating individual willingness to pay are therefore fundamentally misleading as a basis for operationalising the concept of strong sustainability (Common, Blamey and Norton, 1993; Jacobs, 1997). This, then, validates the basic argument of this paper that a discussion of sustainability referring only to definitions is pointless without examination of how the definitions might be put into practice.

2.3 Can a Constant Economic Value of Natural Capital Realise Other Strong Sustainability Objectives?

In the body of work in which the London School of environmental economists (e.g. Pearce et al. 1989, 1990) develop their concept of strong sustainability they also argue that this form of sustainability can realise other desirable objectives, such as inter- and intra-generational equity and ecosystem resilience. In this section, the assertion that the maintenance of the economic value of the earth's natural capital stock would deliver these other objectives is assessed.

In the case of intra-generational equity, one can accept in theory that the preservation of a constant value of natural capital offers one way of breaking the environment–poverty trap where environments are degraded to obtain immediate food supplies. However, in practice, within this kind of market-based analysis it is highly unlikely that the maintenance of a constant economic value of natural capital will benefit the poor or be just to the socially disadvantaged. This is because the valuation of the environment in monetary terms requires the characterisation of environmental goods and services without actual markets as commodities in hypothetical markets. Vatn and Bromley (1995, p. 11) argue that this *commodity fiction* inevitably results in a policy driven by the market, where only those parts of the environment that happen to have value to dominant and powerful agents are selected and bought: 'bald eagles and grand vistas get much more attention – hence become more "valuable" – than an ugly fish or the muddy wetland' (Vatn and Bromley, 1995, p. 12; see also Jacobs, 1994). Hence, by the same logic, it is possible to claim that only those lucky poor who live in environments which are considered by the rich as valuable will benefit from the preservation of the money value of natural capital, since the valuation is necessarily dependent on the distribution of income and the balance of power. The rest are the losers, the ones who bear the net costs of the environmental damage done by the winners, those who benefit from the activity (Boyce, 1994).

Pearce et al. (1990) also argue that maintaining the value of the stock of natural capital intact will realise the objective of ensuring the welfare of future generations as well. While, as noted earlier, the higher prices of environmental goods which may result from the implementation of such an approach are likely to slow resource use and decrease emissions, this argument regarding the welfare of future generations faces three key problems.

First, while the model does not exclude 'all non-self-interested' motivations (Jacobs, 1997, p. 212), it can only incorporate them by turning them first into private preferences and then into money values, so that in the valuation process the needs of future generations are taken as embedded within the preferences of current generations (Hodgson, 1997; Gowdy, 1999).

Second, given that the environmental bequest is one measured in economic not physical terms, the preceding arguments regarding the difficulties associated with this apply in this context also. For example, regarding the role of distribution in price determination, the problem is that the relative price of a good from one period to another depends not only on the preferences of each generation, but also on the endowment of property rights across generations, as shown in overlapping generations models by Howarth and Norgaard (1990) (see also Martinez-Alier and O'Connor, 1999).

The third problem with respect to inter-generational equity concerns the issue of discounting the future. Space does not allow a full discussion of the issue here, so we will do no more than note Norgaard and Howarth's point (1991, p. 90) that there exists a wide range of literature on the determination of the correct rate of discount, but very little on the correctness of the discounting procedure itself. In this context, the key problem with discounting the future stream of costs and benefits, even if the discount rate is zero, is that natural capital is still conceptualised in aggregate monetary terms.

Regarding ecosystem resilience, use of the constant natural capital rule becomes even more problematic when one considers the fundamental uncertainty associated with ecological systems, since the overall information used in the analysis is not rich enough. Thus, Pearce and Turner (1990) advocate that, in the presence of irreversibilities and high uncertainties, a safe minimum standard for environmental quality should apply. Interestingly, Pearce (1998, p. 45) explains how an environmental law can be based on the precautionary principle simultaneously with a cost–benefit analysis. He states that

> the two may be consistent if 'a safe minimum standards' interpretation is allowed: there should be a presumption in favour of not harming the environment unless the opportunity costs of that action are, in some sense, very high. This can be contrasted with the typical cost–benefit rule to the effect that the benefit cost ratio should be greater than unity.

Pearce et al. (1989, p. 56) stress that 'preserving and improving the environment is never a free option: it costs money and uses up real resources'. This means that, as accepted elsewhere by Pearce (1998, p. 45), in neoclassical environmental economics 'some balancing of costs and benefits still must play a role even in contexts where the precautionary principle is thought to apply … whatever rule is adopted it will imply an economic value'.

Clearly, then, whether a cost–benefit analysis, or a safe minimum standard approach, or a combination of the two, is adopted, monetary valuation remains absolutely central because rational decision making on environmental issues, within this theoretical framework, requires that all relevant costs and benefits be priced. Of course, environmental economists are fully aware of the unique characteristics of ecosystems, and state very clearly that many life support functions have no real substitutes, hence the characterisation of some natural capital as critical natural capital. However, the restrictiveness of the methodology they are applying and developing means that they are unable to incorporate these issues within their theoretical framework and are obliged to introduce, at least in principle, ad hoc physical constraints into their analysis. Since such constraints are ultimately incompatible with the underlying theory, this perhaps explains why they are in practice largely ignored. Within neoclassical methodology there can be no theory that deals with long-term environmental uncertainties in a satisfactory manner, since in the end everything turns out to be the subject of preference-based environmental valuation. This again illustrates why operationalisation, the integration of the concept of sustainability within policy and strategy frameworks, makes a crucial difference to the outcome.

Environmental economists believe that the neoclassical framework is the most suitable for the analysis, management and solution of environmental problems. Pearce (1998, p. 3) argues that 'the biggest improvements are to be had through modifications in economics' and adds (Pearce, 1998, p. 5) that 'the approach is pragmatic and focuses on the design of incentives. If it doesn't work we can be sure that nothing will'. However, given the arguments presented in this section, an alternative view is that if one desires to deal with environmental issues successfully and to achieve strong sustainability it is necessary to break free from the mainstream epistemology. The next section turns to the alternative formulation of strong sustainability and its operationalisation within the framework of ecological economics.

3. OPERATIONALISING STRONG SUSTAINABILITY WITHIN ECOLOGICAL ECONOMICS

The analysis of critical natural capital within ecological economics is explicitly different from that found within environmental economics. In contrast to the approach outlined and discussed in the previous section, the emphasis of ecological economics is on the preservation of specific forms of critical natural capital in physical terms, and an insistence on the need for direct, non-monetary, indicators.[7] The ecological economics approach is rooted in a view of the natural world which acknowledges general interdependence, complexity, uncertainty and dynamism, and which locates economic analysis in thermodynamic and co-evolutionary frameworks. The outcome is a search for participatory methods of decision making and an approach which offers the potential of a more problem oriented and policy relevant alternative.

It must be recognised that there is a tension within ecological economics itself about what it comprises, while its interdisciplinary nature also makes a unified methodology hard to define. Nevertheless, in our view there are three crucial unifying elements within ecological economics that distinguish it from neoclassical environmental economics: the co-evolutionary perspective; the laws of thermodynamics; and the means of managing uncertainty and complexity, which embrace post-normal science, procedural rationality and deliberative institutions. These three elements are now briefly considered in turn.

The role of co-evolution and thermodynamics in ecological economics is well-established and well-documented. The former implies a set of equilibrating mechanisms between society and nature (Norgaard, 1984), while the latter involves a view of the economy as embedded within the ecosystem, implying limits on the biophysical flow of resources from the ecosystem to the economic system and then back as wastes (Georgescu-Roegen, 1971; Faber et al., 1996). This latter point is important to note here, in that it involves informational input not directly characterisable in the language of individual preferences.

Regarding uncertainty and complexity, Funtowicz and Ravetz (1990, 1994) argue that contemporary environmental issues are different from traditional scientific problems in the sense that they are global in scale, long-term in their impact, and require urgent decisions to be made based on inadequate and uncertain knowledge. Thus, post-normal science, procedural rationality and deliberative institutions are introduced as ways of managing uncertainty and complexity. For example, ecological economics argues that, when specifying the categories of environmental functions to be protected and setting threshold levels, standard economic valuation methods cannot be used due to inherent uncertainties related to the unpredictability of the complex systems involved and related distributional issues.

Despite this shared basic world view, ecological economics contains clearly divergent views and understandings within it. This diversity becomes especially pronounced in relation to the attitude taken to analyses using different sorts of multi-criteria evaluation and also to the modelling of systems and to resource accounting (Turner et al., 1996; Costanza et al., 1997). Munda et al. (1994) and Martinez-Alier et al. (1998), for example, indicate that it is possible to find in the literature various aggregation procedures characterised by different philosophical and mathematical properties. This is mainly because there are different views about value commensurability/incommensurability. There are also approaches offered as alternatives to monetary valuation, such as some eco-energetic valuation techniques, which are, in fact, other kinds of reductionism. In this context, Martinez-Alier et al. (1999b; mimeo, p. 4) make a classification of concepts and methods in ecological economics according to the criterion of comparability of values, emphasising that

> ecological economics rests on the foundation of weak comparability of values but it also includes (in appropriate cases) other approaches (contingent valuation, or energy analysis, or 'ecological footprint' analysis in terms of land requirement) which taken one by one imply strong comparability and even strong commensurability.[8]

Costanza et al. (1996) see these diverse points of view not as a weakness but, on the contrary, as a major strength of ecological economics. The essential point not to be missed is precisely the fact that ecological economics allows for methodological pluralism and for the articulation of a variety of perspectives, but never has recourse to any one single type of value or takes any particular dimension as the total picture. By using simultaneously several evaluation criteria it compares different options (Martinez-Alier et al., 1998). Although the mathematical and descriptive properties of models differ, Martinez-Alier et al. (1998, p. 282) argue that it is 'the way such models are used and integrated in a decision process' that is important and requires transparency.

Having briefly set out the nature of ecological economics, we turn to its understanding of strong sustainability. Ecological economics calls for the preservation of the physical stocks of certain forms of natural capital, referred to as critical natural capital (Noël and O'Connor, 1998; Faucheux and O'Connor, 1999; Neumayer, 1999). Noël and O'Connor (1998) define critical natural capital as that set of environmental resources which, on a prescribed geographical scale, perform important environmental functions and for which no substitutes in terms of manufactured, human, or other kinds of natural capital exist.[9] In specifying the categories of environmental functions to be protected and in setting threshold levels, it is accepted that standard economic valuation methods cannot be used due to the uncertainties related to the unpredictability of complex systems and also because of distributional issues.[10] It is also acknowledged that scientific analyses alone are not sufficient for making such decisions, since the inherent uncertainty associated with them and the unpredictability of their distributional effects mean that the decisions made will inevitably be affected by the values of those involved.

In the light of this, ecological economics favours approaches that are based on processes and procedures that can bring together the range of information and viewpoints necessary for informed deliberative decision making, as opposed to some mechanistic application of a rule for strong sustainability (O'Connor and Spash, 1999). By dropping the neoclassical maximisation hypothesis and adopting an alternative consensus building strategy, ecological economics tries to guarantee the quality of the decision-making process, rather than concentrating on the final result. This involves deliberation by an extended peer community, including all stakeholders ready for a dialogue, in which the aim is to communicate knowledge, uncertainty and values. Such a process is referred to as procedural rationality, with the peer group discussing and seeking agreement on the relevant issues that need to be considered within the specific context. It is argued that procedural rationality is necessary in order to ensure the legitimacy or, in other words, the social acceptance of the entire process of decision making. This approach is fully consistent with the unifying vision of ecological economics, which implies a fundamental change in the way problems are perceived and how they should be addressed. Specifically, the focus of analysis is shifted from natural resources as commodities in the market system to the biophysical basis of interdependent ecological and economic systems.

In particular, it is argued that the operationalisation of strong sustainability cannot be achieved through the application of the traditional tools of economic analysis alone. It must involve a wider socio-economic policy design, with the new challenge of combining scientific understanding with social values and responsibilities towards absent parties. Accordingly, Noël and O'Connor (1998, p. 81) note that the threshold levels chosen for critical natural capital should be both scientifically plausible and socially acceptable:

> [w]hile having some scientific foundations, we have emphasised that they are inevitably the product of negotiations and hence reflect a compromise of scientific judgements and social preferences for environmental quality…In practice, the selection of the levels of environmental functions to be sustained amount to a choice process that is as much political as technical in nature.

It follows that each decision-making process regarding the environment is viewed as being dependent on a particular institutional context and it is emphasised that decision makers need their own system of indicators, constructed according to the nature of the problem under consideration. In this approach, the quality of the decision-making process is of central importance and the principles on which it is based need to be explicit, transparent and subject to dialogue (Castells and Munda, 1999).

Martinez-Alier et al. (1998, p. 281), as a general rule, state that, 'we do not believe in algorithmic solutions of multi-criteria problems'. They continue by explaining that, '[i]n our view, multi-criteria methods useful for environmental policy must offer a consistent framework aimed at helping the structuring of the problem and the evolution of the decision process' and recommending non-compensatory multi-criteria evaluation techniques where the compensability among indicators is limited and where the possibility of a veto threshold exists. According to Martinez-Alier et al. (1999a, p. 51), an important consequence of noncompensability is that it helps to operationalise the concept of strong sustainability. Having a list of bio-physical indicators and sustainability indexes, far from being just a list of agreed targets or lower limits, also creates 'the possibility of limiting the compensability among indicators and to put lower bounds of acceptability (for example, by the notion of a veto threshold) is of a fundamental importance to operationalise the strong sustainability concept'.

Froger and Munda (1998, p. 174) suggest a very general procedure for the application of the strong sustainability criterion as follows:

> (1) The first step is to recognize multiple 'intermediate and conflictual subgoals' that are irreducible and which must be considered simultaneously…(2) The subgoals in our case can be classified using Herman Daly's (1987) three filters: ecological (or more precisely biophysical), social and economic. (3) Each of the subgoals may itself be broken down into several intermediate goals, which may take the form of standards to be met…(4) The next step is to define a sequential process, where the concern is to identify a 'satisfactory' course of action.

Castells and Munda (1999) use the term Integrated Environmental Assessment for this process, since on the one hand it links the different relevant components and actors of the problem to be tackled, while on the other it suggests a systemic perspective in which different subsystems can be analysed.

As this discussion indicates, ecological economics has a different starting point from that of environmental economics. Its operationalisation of strong sustainability appears more likely to be effective since it targets directly specific forms of natural capital rather than focusing on the maintenance of the value of the aggregate stock of natural capital. At this point, it should be noted that ecological economists, 'do not provide a unique criterion for choice but rather help to frame the problem of arriving at social-political compromise solutions' by offering the means of doing so (O'Connor and Spash, 1999, p. 33). The emphasis on the decision-making and modelling process, rather than on the final decision, does not diminish the importance of the goal.

To summarise, given the fundamental characteristics of ecological economics that have been outlined, an operational procedure for environmental decision making aimed at strong sustainability has been developed based on procedural rationality. The general, but not directly measurable, objective of strong sustainability is operationalised through 'an adequate set of ...intermediate sub-goals together with appropriate means of measuring and achieving progress towards them' (O'Connor et al., 1996, p. 236). The decision-making task is then to search for a satisfactory acceptable solution, given the variety of economic, social and ecological objectives, through an iterative process of identifying trade-offs and compromises using a multiple criteria approach (O'Connor et al., 1996). This may be seen as an extremely difficult process, since there is no unique or universal blueprint. However, although the overall methodology is still in development, it has been argued that the approach of ecological economics has the potential to facilitate the social changes necessary for the solution of environmental problems, which is surely a significant step towards strong sustainability.

4. CAN ECOLOGICAL ECONOMICS ACHIEVE STRONG SUSTAINABILITY?

Given the characterisation of ecological economics above and the acknowledgement that its methodology is still under development, this section will explore whether the critical natural capital interpretation of strong sustainability can be achieved within the ecological economics paradigm. We have argued that the formulation of critical natural capital in physical terms is more likely to be effective than the constant natural capital rule. However, two major lines of criticism have been advanced questioning whether the methodology of ecological economics is at the moment capable of realising its strong sustainability goal. First, it has been suggested that the limited extent to which ecological economics has so far been able to influence real world policy has been due to a separation of the development of technical indicators from the analysis of the economic and political context in which they can be effectively used. Second, and more fundamentally, the possibility has been raised that the distribution of economic and political power within capitalist society is incompatible with the procedurally rational decision-making processes that ecological economics correctly argues are necessary for socially acceptable environmental policies to be made.

In relation to the first criticism, Viederman (1994) reviews the contents of articles published in the ecological economics literature and notes that relatively few are motivated by a concern for policy or are potentially usable in the policy process. He argues that 'we are still more comfortable as a "normal science" rather than as a "post-normal science"' (Viederman, 1994, p. 470). This criticism relates to the fact that the construction of sustainability indices and physical indicators, although a very important part of the analysis, is typically undertaken in abstraction from the decision-making process and the values of those who will make use of them. It will be recalled that the threshold levels and the physical indicators to be used are inevitably the product of a choice process that is as much political as technical in nature. Therefore, without an understanding and perception of the way in which indicators will be used, efforts devoted to their construction are likely to be relatively ineffective. Viederman's conclusion is straightforward:

> [p]olicy involvement is clearly an oft-stated goal of ecological economics, and our defining characteristics support that goal. Unless, however, we make our words a reality, we face the distinct possibility of becoming irrelevant (Viederman, 1994, p. 469).

In a more recent article, M'Gonigle (1999) notes that the orientation of the biannual conferences of the International Society of Ecological Economics (ISEE) and the contents of the society's journal have become increasingly technical:

> [s]ome topics still seek to break new political and strategic ground – from revising the nature of international trade, to constructing new models of human consumption, to elaborating new control regimes for common property resources. But the emphasis is less on refashioning the basic assumptions and institutions of the market economy than on examining specific policies and sectors through an essentially neoclassical prism of monetary exchange values and discount rates. Discussions largely concern such issues as ecological accounting methods…The wholesale challenge to our social institutions that was so apparently necessary in the 1960s and 1970s has almost disappeared from view (M'Gonigle, 1999, p. 12).

M'Gonigle's argument thus connects the first line of criticism, over concentration on technical analysis, to the second, ecological economics to date has not gone far enough in questioning the extent to which its policy approach is compatible with the existing distribution of economic and political power. Most ecological economists take this distribution as effectively given, with the methodology of ecological economics thought of as being complementary to the dominant capitalist market economy.

It is true that some ecological economists have been concerned with distribution, equity and uneven capitalist development (see O'Connor, M., 1994; Foster, 1994; Martinez-Alier and O'Connor, 1999). It is also true that most authors tend to agree that 'sustainability requires the simultaneous application of ecological principles and social justice' (Clark, 1995, p. 242). However, while their perspective without doubt sheds light on the impact of power structures and on the design of institutional settings that affect environmental policies (Söderbaum, 1992; Opschoor and van der Straaten, 1993), as Liokadis (2000) points out, their approach remains incomplete. They examine neither the class contradictions underpinning social change nor the social and political preconditions for the establishment of procedural rationality, discursive democracy and social justice. In their methodology, negotiations and the search for societal consensus over key environmental issues are incorporated into the overall capitalist market economy.

This leaves open the question of whether the capitalist market economy and the social-deliberative mechanisms proposed are compatible. Dialogue and informed participation by all affected parties need to be between equals if they are to result in sustainable policies. Discussing the need to deal with negotiation failures that occur due to asymmetries in bargaining power, Dryzek (1994, p. 194) notes that,

> [e]xactly how that might be accomplished without the heavy hand of the administrative state is a major unresolved issue, made especially problematic by the ability of capitalist and market systems to punish political decisions that impinge upon their logic of accumulation.

Viederman (1994) further indicates the specific challenge to which ecological economics must rise in order to contribute effectively to the political and policy process:

> [i]mplicit, and to be made much more explicit, is the assertion that there can be no real sustainability without equity, within and among the nations of the world. Without equity there is no political stability.

This has led O'Connor, J. (1998) to question whether, in the end, it is possible to have sustainable capitalism. This issue is central to any attempt to evaluate the criticism of ecological economics that it is at present unable to realise its objective of strong sustainability. Liokadis (2000, p. 71) argues that,

> if the environmental problem is to be effectively faced, any investigation should be directed towards questioning the capitalist relations of production themselves, and rejecting the social and environmental implications of uneven capitalist development. Only in the context of an alternative social and international setting could international economic relations be properly formed to allow a geographically balanced, dialectical relation between society and nature.

Similarly, O'Connor, J. (1998, p. 127) argues:

> [w]e need a theory that gives due consideration to both systematic economic forces and social and political movements and that deploys ecological science, political economy, and sociological theories of social movements and change as well as the everyday experiences of people. Above all, we need a theory that identifies ecological and other contradictions of capitalist development, in ways that illuminate and advance ecological and related social movements. This is a tall order.

Finally, as M'Gonigle (1999) notes, the challenge these authors are making is not a technical one but rather a profoundly political and social one. The overall direction of the change needed, they argue, is away from free trade-based regimes towards community-based forms of territorial self-maintenance, enhanced by the communisation of productive territorial wealth, by the equalisation of access to the bases of social and economic power. What this implies is that ecological economics needs to situate itself within a larger political economy and search for new models of economic development that reflect the needs of both ecosystem integrity and community health. Several alternative political and social options have been discussed, but the way forward with respect to environmental problems, on this analysis, once the distributional issues have been addressed, lies mainly in focussing on the institutional context within which information is obtained and exchanged, co-ordination is conducted, and decisions are made (Devine, 1988, 1992; O'Neill, 1998).

5. CONCLUSION

The objective of this paper has been to show that a discussion of sustainability in terms of definitions alone is incomplete without evidence on how they are to be operationalised. The underlying methodology of neoclassical environmental economics, based on environmental valuation deriving from exogenous individual preferences, is unable to incorporate critical natural capital as an integral part of its analysis. It therefore introduces physical measures of elements of critical natural capital into its definition of strong sustainability as constraints, but necessarily on an ad hoc basis. Thus, when it comes to operationalisation it effectively ignores the constraints and concentrates more or less exclusively on the maintenance of the value of the natural capital stock.

Ecological economics, by contrast, focuses explicitly on physical indicators of critical natural capital. It embraces a view of the natural world as characterised by interdependence, complexity, uncertainty and dynamism, and situates economic analysis in a thermodynamic and co-evolutionary framework. Ecological economics advocates participatory methods of decision making and offers a problem-oriented and policy-relevant framework for operationalising strong sustainability. It adopts a consensus-building strategy, through an extended peer community, and emphasises the quality of the decision-making process rather than concentrating on the final outcome. Although it utilises many techniques from other disciplines, when constructing different types of physical indicators and multi-criteria decision aids it takes multiple values into account and seeks to avoid the reductionism involved in attempting to arrive at an aggregate valuation of the stock of natural capital as a whole.

Finally, the paper discussed the criticism that ecological economics, despite its strengths, has so far had relatively little success in promoting the achievement of strong sustainability. This criticism arises because of doubts over the extent to which the participatory decision-making processes recommended by ecological economics are compatible with the capitalist market economy. Thus, it has been claimed that ecological economics deals only partially with the problem of how to operationalise strong sustainability since it has so far not been based on an analysis of the political economy of capitalism, of the socio-economic dynamic of the prevailing global system. Further research evaluating this criticism is needed in order to clarify the nature of ecological economics and, more importantly, to develop increasingly effective tools, techniques and processes for natural resource and environmental management.

NOTES

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[1] Hereafter referred to as environmental economics.

[2] In the strong sustainability approach, natural capital is regarded as being fundamentally non-substitutable (Turner, 1993; Neumayer, 1999). The weaker versions of sustainability are consistent with a declining level of environmental quality as long as other forms of capital are substituted for natural capital.

[3] There exist a number of differences in approach and emphasis among those working in the area of ecological economics (Spash, 1999; M'Gonigle, 1999), something which Costanza et al. (1996) regard as a strength. A short characterisation of what is being referred to in this paper as 'ecological economics' is provided in Section 3. Of course, ecological economists share many of the techniques used by environmental economists and there is much overlap in the work of scholars from both approaches. A recent example of this is the EU project, CRITINC, 'Making Sustainability Operational: Critical Natural Capital and the Implications of a Strong Sustainability Criterion' (see Ekins 1993; van der Perk, et al., mimeo). In our view, as Section 3 makes clear, what makes ecological economics distinct is its insistence on incommensurability and the primacy of critical natural capital measured directly in physical terms. However, we recognise that not all ecological economists accept this approach.

[4] In fact, Pearce (1998, p. 46) argues that strong sustainability is a two-part requirement 'not only must natural capital be constant but so must the aggregate stock'. He notes that '[o]therwise we would regard an economy with ever increasing natural assets as sustainable, regardless of whether knowledge is lost and buildings decay'.

[5] The other possibilities are: first, the unit value of the resource/service (as measured by a price); and second, the total constant value of resource/service flows obtained from the stock (where the resource flow is the product of price and quantity used) (O'Connor, M., 1998; Pearce and Turner, 1990; Victor, 1991). The problems associated with these definitions are discussed in Pearce and Turner (1990) and Victor (1991).

[6] In Boyce (1994, p. 171) power is defined as 'the ability to bear transaction costs'. For example, he predicts that, 'waste-disposal facilities will be sited in the least powerful

communities, or in Coasian terms, in communities whose residents are least able to bear the transaction cost of rejecting such facilities'.

[7] It is important to note that there may be social as well as physical reasons for defining natural systems as critical natural capital. It should therefore be kept in mind that, in addition to the most fundamental global life-support resources, such as biodiversity and the ozone layer, some other components of natural capital might be categorised as critical through the social choice processes advocated by ecological economists.

[8] In order to clarify the terms, it is useful to note that, from a philosophical perspective, O'Neill (1993) distinguishes between the following concepts: strong commensurability, according to which there exists a common measure of the different consequences of an action based on a cardinal scale of measurement; weak commensurability, according to which there exists a common measure based on an ordinal scale of measurement; strong comparability, according to which there exists a single comparative term by which all different actions can be ranked; and weak comparability according to which values are irreducibly plural and cannot be uniquely ordered along a single scale.

[9] Noël and O'Connor (1998) define the concept of environmental function as the capacity of natural processes and components to provide goods and services which satisfy human needs. In Neumayer (1999), the key issues regarding natural capital are identified as preventing large-scale biodiversity losses, preserving global environmental life-support resources, such as the global climate and the ozone layer, limiting the accumulation of toxic pollutants, and restricting over-harvesting and soil erosion.

[10] These threshold levels may be defined either quantitatively or qualitatively, depending on the nature of the services furnished. The aim is to have a measure of the actual situation and the thresholds supposedly not to be crossed (Noël and O'Connor, 1998).

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