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THE COSTS OF ACHIEVING SUSTAINABILITY

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THE COSTS OF ACHIEVING SUSTAINABILITY:

The Differences Between "Environmentally Corrected National Accounts" and "Sustainable National Income" as information for Sustainability Policy

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ABSTRACT

The emergence of the concept of sustainable development has encouraged economists and decisionmakers to look at the the extent to which established systems for national accounting (SNA) can be modified to take account of concerns for ecological sustainability. In this paper, we examine carefully definitions of, and methods for arriving at, "corrected aggregates" -- variously called "Green GNP", "environmentally corrected national income" (ENI), and"sustainable national income" (SNI) -- and their relationships to the "weak" and "strong" criterion of sustainability. In particular we consider the relation between an estimate of a SNI, and various measures that have been proposed for estimating an "environmentally corrected national income" (ENI). Two main types of ENI "correction" methodologies are distinguished and discussed: (i) those based on capital theory and the idea of accounting for depreciation of "natural capital" stocks; and (ii) those based on identification in biophysical, ecological and social terms of norms for sustainability, with subsequent estimates of the costs of achieving these norms. Our main conclusions are: (1) with careful applications, these two approaches can be regarded as complementary for the estimation of an ENI; (2) in no instances do these measures of an ENI correspond to estimations of SNI for a country. Rather, the existing ENIs can be regarded as embodying information about the "costs of achieving sustainability" given the existing capital stocks and about the "distance separating a country from sustainability". Conceptual and empirical estimation work should proceed by exploring the relationship between ENI and SNI as distinct and complementary policy reference points.

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1. Introduction

There is a general consensus on the deficiencies of the existing systems of national accounts (SNA) to take account of environmental sustainability preoccupations.[2] At present, there exist a wide range of different ways of trying to integrate environment and ecological sustainability concerns into revised frameworks of national accounting. Den Butter & Verbrugen [1994] identify two main poles between which approaches may be placed. The first consists of calculating some version of a "green GNP" or "sustainable national income" in monetary terms; the second aims at providing indicators of the state of the environment in physical or ecological terms, placing these indicators for comparison alongside GDP growth or other measures of economic performance.

In this paper, we try to clarify to what extent, and in exactly what sense, the various proposed measures of "environmentally corrected national income" (henceforth ENI) take into account the requirements for ecological and economic sustainability of development. Much current work seems to proceed on the basis of trying to obtain an overall indicator of the sustainability potential of an economy through the construction of a corrected aggregate which is described as a *"sustainable national income" (SNI)*. But the terminology is misleading. While "sustainable national income" has a precise theoretical meaning and is certainly a concept warranting further to be explored, the existing methods of obtaining an ENI actually have a different meaning. The ENIs can be regarded as embodying information about the the overall costs (opportunity costs for the economy or for consumption) that would be associated with achieving sustainability, given the existing capital stocks . Thus they yield a measure of what we call *"costs of achieving sustainability,"* and the *"distance separating a country from sustainability"*. Our paper is devoted to explaining the difference between ENI and SNI, and the utility -- both conceptual and empirical -- of working with both concepts as reference points in formulating sustainability policy.

Section 2 discusses briefly the theoretical notion of a sustainable national income (SNI) in the context of models of capital accumulation, distinguishing three categories of economies:

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[2] The urgent need for revision of the SNA is underlined further by the 5th programme of the EEC for the environment and sustainable development, which makes a call for the elaboration of adjusted national accounts, supposed to be available on a pilot basis from 1995 for all countries of the European Union (see COM [1992], 23, final vol II). Similarly, the Agenda 21 adopted at the UNCED Earth Summit at Rio de Janeiro in June 1992 insists on the necessity for improving environmental data bases in order to establish a proper system of economic-ecological accounting.

those unable to achieve any sustainable timepath; those with a potential for unlimited growth in total capital stock; and those capable of a long-run stationary level of capital. Section 3 reviews methods for constructing an ENI based explicitly on notions from neoclassical capital theory, in particular the "weak sustainability" approach. Section 4 examines Hueting's approach based on identification in biophysical, ecological and social terms of norms for sustainability, with subsequent estimates of the costs of achieving these norms. This analysis in terms of adjustment costs for meeting sustainability norms can, at a formal theoretical level, neatly be reconciled with the "strong" sustainability version of the capital theory. Section 5 discusses the interpretation of these various ENI concepts and measures, and suggests that the "strong" approach in term of adjustment costs for meeting sustainability norms and the "weak sustainability" approach can, at a formal theoretical level, be regarded as complementary in the estimation of ENI. However, in no instances do these measures of an ENI correspond, strictly speaking, to estimations of an SNI for a country. Conceptual and empirical estimation work should, therefore, proceed on the basis of further clarifying this distinction between ENI and SNI, and the relationship between them as *distinct and complementary* policy reference points.

2. Natural Capital and Sustainable National Income.

The usual way of defining sustainable development within a strictly "economic" framework is in terms of non-decrease over time of the level of utility, or income per capita, or real consumption per capita (cf. Mäler [1991]). Such an interpretation is closely related to the Hicksian definition of a person's income as the amount he/she can consume during a specified period, while ensuring that his/her wealth at the end of the period is no less than his/her wealth at the outset (Hicks [1946]). By analogy, we can state that achieving sustainable development is possible if, and only if, the total stock of capital (or, depending on the exact model specification, capital per person) passed on from one generation to the next can be maintained remain constant or increasing through time[3]. The key idea behind what we may call the "Hicksian sustainability rule" is that a non-decreasing bequest of capital from one generation to the next provides the basis for non-decreasing consumption from one period (generation) to the next. Hence there is a direct connection between the "capital stock maintenance" criterion and the idea of a "sustainable national income". The "sustainable national income" (henceforth

[3] Some care is required in extending Hicks' concept to the sustainability domain. In the original context of application the individual firm was typically a price-taker, so capital stocks could be valued with reference to exogenous price levels. This is no longer so when resources management involves questions of changes in natural capital use patterns for whole economies over long periods of time.

SNI) for an economy is, in effect, the value of goods and services that may be *consumed* (rather than conserved/reinvested) in a given period while the economy-system still furnishes the basis for providing (at least) the same level of real consumption in every period through the future.

Now, in an inter-temporal general equilibrium (that is, with equalisation of opportunity costs on all margins), the value of the total capital stock passed on as a bequest from one period (or, let us say, one generation) to the next, is always equal to the value (using the time-discount rates applying to the equilibrium) of the sum of the consumption flows in the future that it furnishes (Fisher [1933]). So, where "inter-generational equity" is provided for in the sense of an inter-temporal equilibrium with equal consumption provided for each generation, we will also have -- making the assumption for simplicity that the time-discount rate between periods is also constant from one period to the next -- a constant value for the capital stock. Such a situation would represent a stationary state upon which the economy converges, stationary in terms of both the annual income and the total value of capital stock.[4]

In a model economy that permits unlimited growth of the total capital stock through time, it will generally be possible to increase the "sustainable national income" for the future, by, provisionally, restraining consumption below the current "sustainable income" so that the total capital stock is built up. This is indeed the presumption behind traditional macroeconomic modelling that discusses the "trade-off" between current consumption and growth rate. But once we introduce environmental constraints such as finite stocks of non-renewable resources, or finite stocks of renewable natural capital providing either raw materials or environmental services, the problem becomes more delicate. As discussed in the literature (see Toman et alii [1994]), the growth and/or sustainability potentials for the economy depend strongly on the specific assumptions made about natural capital renewal rates, elasticities of substitution between natural and produced capitals, technical progress augmenting productivity of capital(s).

The question thus arises, what determines the maximum "sustainable national income" that might be obtained? To answer, we should divide economies into three categories:

2.1 those incapable under any circumstances of maintaining a positive and non-declining capital stock level in the long-run;

2.2 those capable of unlimited capital growth at a positive rate;

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[4] Change over time to the composition of annual consumption and of total capital stock is not necessarily precluded.

2.3 those capable of sustaining some sort of long-run steady-state (zero-growth) based on maintaining "optimal" stocks of renewable natural capital.

We will discuss the distinctive character of the possible "sustainable national income" for each of these categories in turn.

2.1 Models of economies incapable of sustainable time-paths.

The intuitive meaning and relevance of models that provide no prospect for a long-run sustainable timepath, is the representation of economies whose activity progressively destroys a needed natural capital but which lack any technological capability for eliminating this destructive feature. One might imagine, generally speaking, the problem of a natural capital such as the atmosphere that is needed as a strictly complementary input for economic production/consumption activity, but that is irreversibly degraded by the production/consumption process -- for example, poisoned or rendered unliveable by toxic emissions such as nuclear wastes, where the recovery rate is negligible compared with the rate of toxification damage (a neo-Ricardian model portraying such a situation is found in O'Connor [1993]). In such economies, it is impossible to have long-run sustainability of economic production, and an inter-temporal path that maximises present value of consumption will necessarily be characterised (beyond a certain period) by monotonically declining value of total capital stock. Thus there is no positive "sustainable national income".

One might of course argue that there is always the possibility of foregoing such noxious technologies, it is just a matter of accepting the opportunity costs of doing so. The problem thence is transformed into whether, politically and socially speaking, people are willing to bear the "adjustment costs" of shifting to environmentally benign technologies and consumption patterns.

2.2 Models with unlimited growth potential.

Let us now consider the other extreme. In models where "technical progress" and/or elasticities of substitution are made high enough, the value of the economy's capital stock may grow without limit, and the "sustainable national income" is correspondingly unbounded "in the long run". In any particular period, however, consumption in excess of the national income represents a (temporary) set-back for the economy. In essence this amounts to "living off capital" during the period in question. While this may delay overall economic development, no permanent damage is done if it is a "temporary" set-back. The problem becomes serious (from a capital accumulation point of view) if the living-off-capital is repeated period-after-period, thus becoming a trajectory of economic decline. Formally, one can construct models where there exists the technological capability for unlimited growth over time by substituting away from a renewable or non-renewable natural capital, but if we assume a sufficiently high time-preference for present consumption over future consumption, then we may obtain an inter-temporal equilibrium path characterised (beyond a certain period) by monotonically declining values for total capital stock, and we will correspondingly have declining consumption levels. (Howarth & Norgaard [1992] and Mourmouras [1993] furnish examples of such model trajectories; see also the discussions by Toman et alii [1994]).

2.3 Models with bounded sustainability potential.

In models where, by contrast, it is supposed that substitution away from natural capital is not possible, the maximum long-run sustainable level of total capital stock is determined by natural capital stock levels and/or renewal capabilities. For example, we may assume complementarity between economic produced capital and natural capital that, depending on the way that it is used, can be either reproduced in situ or irreversibly degraded. Or we may have a sustainable regime based on maintaining the maximum rate of renewal for a self-regenerating natural capital stock required as a complementary raw material input or waste disposal service. (Such a result may typically be obtained if for example one assumes a logistic renewable-rate function for a complementary natural capital input, or an upper bound on the level at which a complementary waste assimilation function can operate.) Therefore the maximum "sustainable national income" will be the consumption level (and the distinctive choices of technology and/or product mix) associated with the economy actually moving along such a "steady-state" path. Of course, the economy may "over-consume" relative to this level (see for example Hartwick [1991].) Given the assumptions about non-substitutability away from natural capital, this necessarily amounts to "living off natural capital" as Daly [1991] has often put it; and the question will again arise, what measures may be proposed to estimate the magnitude of this "over-consumption".

2.4 Sustainable national income (SNI) versus costs of adjustment (CAS).

These comments provide a backdrop for our appraisal of the utility and limitations of both the capital theory approaches and the costs-of-adjustment approach of Hueting and others. The requirement that arises for national accounting, is to have meaningful estimates of what the "correct" national income is in a given period, taking full account of depreciation and/or consumption of all categories of capital, both natural and produced. On this basis one can estimate by how much an economy is "living off its capital". In this respect, using environmentally corrected national accounts amounts to extending the traditional developmentalist concern about capital formation to include so-called natural capital. However, it is important to take care to ensure that the relationship between the valuation of this depreciation and the underlying concern for sustainability, is established correctly and without ambiguity.

In models where sustainability is feasible either as "sustainable growth" (as implicitly envisaged by the Brundtland Report [WCED 1987]) or at an ecologically bounded level, but in either case problematical because of the possibility of living-off-capital, two distinct sorts of accounting questions arise. These are questions of how to arrive at estimates of, respectively :

(a) what the possible level(s) of a "sustainable national income" might be? and

(b) "how far from sustainability" the economy presently is?

The theoretical basis for an answer to the first question has already been indicated above, although of course empirical estimations encounter difficulties relating to specification of technological change possibilities, ecological limits and (in)stability, uncertainties, and scenarios about lifestyle/consumption choices. But what is the basis for an answer to the second question? Several complications arise here, which relate partly to empirical problems about estimating requirements for a sustainable path (that is, giving an answer to the first question), and partly to the fact that we are necessarily comparing two different regimes of economic-ecological activity. In model terms, we will be comparing:

(1) a hypothetical sustainable time-path (which, we will assume, will be characterised by a particular set of shadow-prices), with

(2) a period or periods of actual economic activity that, by hypothesis, are trending in directions incompatible with long-run sustainability.

The question arises, in what ways should we employ (i) the sustainability shadow prices, (ii) actual market prices, and (iii) shadow prices for erstwhile unpriced environmental capital based on estimates of "willingness to pay" etc., in making calculations of values of capitals depreciated or augmented, etc.? This problem needs clear answers at both theoretical and practical levels.

Hueting [1991, pp.206-211] has pointed out this complication about the choice of prices and reference economic activity levels in making estimates of, for example, "costs of adjustment" to respect chosen ecological norms. It is partly for this reason that he insists that his chosen method making use of existing prices -- essentially a concatenation of partial equilibrium analyses -- represents only a rough and ready pragmatic approach to calculation of an ENI. The question seems to have received less attention on the part of those using capital theoretic approaches. However, Hartwick, in the context of a Ricardian model of degradation of environmental capital where steady-states in the sense we discuss here are a feasible class of outcomes, comments rather tersely that "To move from our abstract ideal valuations to actual valuations is very difficult. When inputs are improperly priced [relative to a sustainability path], the wrong levels of outputs are produced at the wrong prices" (Hartwick [1991, p.649]). He suggests, nonetheless, that "trends in an adjusted NNP would provide a better indicator of how a nation's welfare is changing over time than say current NNP unadjusted for natural resource stock appreciation" (Hartwick, [ibid.]). While this assertion seems plausible, it still leaves unresolved the question of what exactly is being estimated in the course of constructing "environmentally adjusted national accounts" and thus a figure for an ENI.[5]

Leaving the technical aspects of valuation and measurement methodology momentarily aside, we suggest an answer as follows. The "greened" or environmentally adjusted national accounts do not in themselves furnish the basis for estimating a "sustainable national income" (SNI). Rather they furnish the basis for estimating "costs of achieving sustainability" which can be regarded as a measure or indicator of the "distance separating a country from sustainability." First, in instances where, according to the "weak sustainability criterion," estimates are being made in monetary terms of the depreciation of a country's stocks of natural capital, prima facie an estimate is being made of the value of product that should be foregone from current consumption in order to respect a sustainability norm. Second, Hueting's method of estimating costs of respecting defined sustainability norms, provides the basis for obtaining a measure a "distance from sustainability" in terms of "costs of adjustment".

In both instances, the construction of an ENI corresponds to the estimation of the "opportunity costs" in terms of current consumption that would have to be foregone (relative to "business as usual") in order to place the economy on a path of "adjustment towards sustainability". As such, the ENI does not necessarily tell us much about the magnitude of the SNI associated with a conceivable path of sustainability, were this latter to be attained.

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[5] Most of those authors appproaching the definition and measurement of "sustainable national income" directly in terms of capital theory concepts (such as total capital stock, total economic value, scarcity rents, etc.) neglect the mis-measurement problems to which Hueting and Hartwick allude and which we try systematically to explain here. To what extent, and in what circumstances, one might justify "first stabs" at corrections as being warranted for pragmatic policy impact objectives, is a priori unclear. Precisely because the significance is unclear, some reflection is desirable.

For example suppose that, in the respective approaches, estimates for natural capital depreciation or estimated costs of meeting environmental norms are quite high, one arrives at a figure for environmentally adjusted national income for the period (ENI) that is negative. This suggests that, in terms of maintenance of capital stocks (under the conventions of valuation and measurement adopted in each instance), the country is going backwards. This is, obviously, an important indicator for policymaking (see section 4.2 below). But, also obviously, this indicator does not reveal the *potentiality* (or perhaps lack of it) of the economy-environment to support a positive SNI through changes in technology, investment commitments, and consumption patterns. As regards this latter, a recent unpublished paper by de Boer, de Haan & Voogt [1994, p.2] poses the pertinent question:

"What maximum net domestic product (NDP) is generated in an economy in which the burden on the environment is reduced to a sustainable level and which has re-entered an equilibrium state?"

These authors note also [ibid.] that "the period of transition is not reflected in our model." We add the point, therefore, that in principle "costs of adjustment" (that is, costs of transition) could be expressed as opportunity costs with reference either to the hypothetical sustainable equilibrium or to the actual non-sustainable situation (which pro forma may be interpreted as a beggar-the-future inter-temporal equilibrium). We will now show that most of the measures of an ENI proposed up until now fall into this last category, of "costs of adjustment" measured in prices or shadow prices pertaining to the current (non-sustainable) situation.

3. Total Capital Stock and the "Weak" Criterion of Sustainability

Many authors (for example Repetto [1989]; El Serafy [1991]; Peskin [1991]; Solow [1992]) have suggested possible indicators of sustainability based on corrected national economic accounts taking account environmental assets in monetary terms. There is not total agreement on the exact nature of the corrections that should be made,[6] but the several

[6] For example there are differences of opinion and practice as to the elements to be included within the enlarged system of national acccounts (depletion of natural resources? environmental damages? expenditures on environmental protection?), and also as to the manner in which these elements are included (for example, should defensive expenditures appear as future or intermediate consumption?).

propositions for revising the system of national accounts in monetary terms have a common conceptual basis in neoclassical capital theory. However, the capital theory approaches divide into two variants, based respectively on the "weak sustainability criterion" presuming substituability between produced and natural capitals, and on the "strong sustainability criterion" presuming some sorts of "critical" natural capitals are non substituable and whose stock levels are to be maintained. We will firstly show that the propositions of modified accounting aggregates -- essentially amounting to the deduction from the GDP of depreciations in both manufactured and natural capital stocks -- are linked with the "weak" sustainability version of the capital theory, and move from there to evaluate the utility and the limits of theses propositions (section 3.1). From there, we emphasise the necessity of implementing a "strong" sustainability version of capital theory (section 3.2).

3.1 "Weak" sustainability and the valuation of natural capital depreciation.

What has become known as a "weak sustainability criterion" (cf. Turner [1993]) is the maintenance of the total stock of capital -- composed of K_m (manufactured or reproducible capital); K_h (human capital, or the stock of knowledge and skills); K_n (natural capital: exhaustible and renewable resources, environmental services) -- through time with the implicit assumption of unlimited substitution possibilities between manufactured and natural capitals. So we have :

$$dK/dt = d(K_m + K_h + K_n) / dt \geq 0 \qquad (1)$$

The Hartwick Rule [Hartwick 1978] may also be applied to regulate the transfers of capital between generations in the goal of sustainability. In effect this rule stipulates that the rents obtained from exploitation of natural capital by the present generation, ought to be reinvested in the form of reproducible capital to be transmitted to future generations at levels sufficient to assure the maintenance of real consumption levels through time.

In such a perspective, these authors propose the following "environmentally adjusted national income" (ENI). It is equal to the conventional GNP (Y) minus the depreciation of capital stock. Since we have distinguished between economic producible capital and natural capital, we may define it in the following way:

For an indication of current debates, see Markandya & Perrings (1991), Sterner (1993), and Liepert (1994). One of the tasks of the DG-XII project, "Methodological Problems in the Construction of Environmentally Adjusted National Income Figures", is to come forward with some workable solutions on these points, on both theoretical and empirical estimation levels.

$$ENI = Y - \delta_m K_m - \delta_n K_n \quad [7] \qquad (2)$$

The trouble is, this ENI can **not** validly be interpreted as an estimate for the SNI of the economy, because the elements on the right hand side of equation *(2)* are all related to stock levels, production and consumption patterns, and relative prices for a situation "far from sustainability".

Turn to the theoretical underpinnings for valuation of natural capital depreciation. The "weak sustainability" indicators clearly have their origin in neoclassical capital theory. This implies the adoption of common evaluation principles for the depreciation of the different types of capital, since these are all treated in a formally identical way.[8] The unit of valuation is a money unit, so it is a question of prices. In this context, two important issues arise. The first is how to deal with environmental stocks and services that are not priced at all. The second is to know whether or not the prices or shadow prices by which natural capital depreciation is estimated, are indeed compatible (in concept at least) with a sustainability norm.

Look first at the construction of (shadow) prices. In the context of evaluation of natural capital depreciation, the distinction is usually made between commodity natural capital already managed under the price system (such as depletable resources and some renewable resources like forests) and what we may call non-commodified natural capital (renewable resources like air and environmental services, in other words amenities and assimilation capacities of the biosphere).

The notion of scarcity rent as defined in the theory of exhaustible resources is habitually invoked, implicitly or explicitly, as a basis for measuring the depreciation of commodified natural capital within the framework of revisions to national accounts aimed at gauging weak sustainability (Pearce & Atkinson [1993]; Solow [1992]). The scarcity rent, also called the marginal user cost,[9] can be expressed -- in the inter-temporal present-value maximisation schema inherent in the underlying models of depletable resource use -- as the shadow price of this resource (measuring its opportunity cost in the inter-temporal equilibrium) less its marginal extraction cost (Hotelling [1931]).

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[7] On can (for simplicity) propose that $\delta_h = 0$, since knowledge and skills are presumed not to depreciate over time.

[8] As Hartwick (1991) suggests, an advantage of capital theory is that it allows the same treatment of the problem of accounting for the waste or degradation of environmental capitals as of stocks of renewable and non-renewable natural resources.

[9] The marginal user cost of the stock resource is defined as the amount by which the present value of the resource at date t is reduced (increased) when an additional unit of the resource is extracted (conserved).

A number of criticisms have been made of this valuation logic, and more particularly of the often sloppy way that it is employed. A first criticism concerns the incorrect information furnished by actual market prices as a presumed proxy for inter-temporal opportunity cost, and the nonavailability of data necessary for the calculation of marginal user cost (see Norgaard [1990]; and note the remark cited above from Hartwick [1991] on the difficulty of moving from theoretically correct framing of the problem to measurements using actual prices). A second criticism pertains to the evident fact that allocative efficiency and sustainability do not necessarily coincide (see Clark 1991). As Howarth & Norgaard [1992, p.476] have expressed the point:

"Reasoning from a general-equilibrium framework, we [can] show that the valuation of environmental services and how society cares for the future are interdependent. Valuation [that is, pricing at opportunity cost] when there is too little caring for the future (i.e., too little asset transfer) will not lead to sustainability."

It is therefore very probable that depreciation estimates using current prices are systematic mis-valuations (on the low side) compared with valuation obtained with reference to a sustainable resource allocation path. In particular, the method of simply substraction of estimates of depreciation of commodified natural capital (valued in market prices) from conventional GNP, pays no attention to the fact that, according to the underlying theory, the "correct" time-discount rate (reflecting inter-temporal opportunity costs) is itself sensitive to which inter-temporal equilibrium the economy is moving along (see Howarth & Norgaard [1990, 1992, 1993]). Supposing that the time-discount rate associated with a sustainable natural capital use regime may be significantly lower than that associated with an impatient boom-and-bust (beggar-the-future) equilibrium path, these accounting methods under-value the natural capital depreciation by comparison with opportunity costing in a sustainability regime.[10]

For non-commodified capital, all sorts of problems arise, several in addition to those mentioned above, in the attempt to put a value to depreciation.[11] Some analysts, like Solow [1992], in order to preserve the applicability of capital theory, argue for an extension of the

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[10] For further appraisal of some of the practical merits and limitations of this approach, see also Scherp (1993, p 23). It might be argued that, since the correction is "in the right direction", this may not matter too much. Our point however is that it seems valuable to gain some insights, both theoretical and empirical, into how significant this mis-valuation might be.

[11] A good number of proposed versions of "corrected NNP" don't even take into account this category of natural capital, citing (among other reasons) the difficulty of valuation! This adds insult to injury.

notion of scarcity rent to this type of natural capital. While this is formally valid, the difficulties with such an attempt should be made clear.

Most non-commodified natural capitals are, in reality, treated as "free access" and are characterised by absence of any market prices, and non-existence of access costs (by contrast with depletable resources for which there are costs of extraction). The theoretical solution for getting around this difficulty is to attribute some sort of shadow price to this type of capital. This runs us up against problems of finding the "right" shadow prices, which means in effect deciding the "correct" specification of the "good" in question and of property rights. In the case of a "public" environmental good, we may adopt the perspective of a Lindahl equilibrium (Mäler [1985]), or alternatively, we may pro forma suppose privatisation. Either way, we have to take account of the notion that adopting a sustainability norm awards "rights" to future generations. By hypothesis, this contrasts with the status quo pattern of economic activity which heavily "discounts" the future by failing to give much weight to the future generations' probable demands for natural (and economic) capital and services derived therefrom.[12]

If, pro forma, we suppose that access rights are awarded to all generations in a way consistent with inter-temporal equity norms, this overcomes the "free access" problem and the equilibrium obtained will formally correspond to a sustainable development. In reality this would correspond to some sort of comprehensive conservation, investment, or environmental protection programme. Alternatively, we might suppose that specified individuals or agents control access to the environmental stock providing the service, in which case we can ask what is their WTA for foregoing any use that degrades or depreciates the flow of services. The valuation problem may then be considered as a sort of mirror-equivalent of the situation with equating extraction costs plus scarcity rent to opportunity cost in the case of a commodified natural resource stock. The capital depreciation due to depleting a unit of a natural resource stock is the difference between its "correct" shadow price and the marginal costs of extraction, or in other words the scarcity rent. Correspondingly, for a unit on the margin of environmental degradation (here presumed to be reversible through environmental restoration and/or protection), one can think in terms of equating the shadow price (marginal value to users) to the

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12 We repeat that one would expect, other things equal, marked differences in key relative prices (including the discount rate) for comparative inter-temporal equilibria expressing (i) inter-generational equity norms and (ii) a "beggar-the-future" regime of activity. So, again putting things formally, in this context the differences between present values for inter-temporal WTP and WTA measures relating to demand for environmental goods and services, may be expected to be considerable. We know of no formal modelling in the published literature that states these results as such, with explicit refeerence to valuation for national acccounting. But the key ideas can be inferred by a synthetic reading of Howarth & Norgaard [1990, 1992, 1993], Mourmouras [1993], and Mäler [1985], among others. A paper currently in preparation Muir & O'Connor [1994] explores the WTP/WTA discrepency issues in the framework of a simple general equilibrium model with a production externality.

WTA plus quasi-scarcity rent for the non-commodified natural capital. The idea of using marginal restoration costs as a proxy for shadow price (value on the margin) is valid in theory, subject to the caveat of (i) defining coherently the reference general equilibrium states (hypothetical sustainable path, and actual beggar-the-future path, respectively), and (2) being careful about the infinities that can arise on-the-margin when degradation is irreversible (for fuller discussions see Castells-Cabré, Froger & O'Connor [1994]; Muir & O'Connor [1994]).

The reference-state issue can be portrayed as in **Graph 1** below. The horizontal axis represents the quality of non-commodity natural capital in physical terms, and the vertical axes shows costs and prices. Let us suppose that the demand curve marked D_P represents willingness to pay or willingness to accept as revealed by "users" with status quo income distribution and market prices. The higher demand curve D_S corresponds, by contrast, to the valuation of the environmental good/service where rights/income distribution is appropriate for inter-generational equity. The two curves marked MC_P and MC_S are the respective estimates of marginal restoration/protection opportunity costs.[13] This illustrates the proposition that WTP/WTA valuation biased by status quo prices and rights/income distribution may be expected to lead to a lower estimate of the value of environmental damage and/or a lower level of environmental quality/protection than evaluation and Pareto-optimisation based on sustainability norms. The intersection of curves MC_P and D_P does not correspond to a sustainable equilibrium. If the curves' relative positions are as drawn, then relative to the sustainability situation given by the intersection of curves MC_S and D_S, the environmental capital is underpriced in estimation of the environmentally adjusted national income.[14]

Refer Graph 1:

Valuing depreciation of non-commodified natural capital.

The important point here is that so-called social wealth-maximisation is definable only relative to the endowments/rights structure. It is clear from the above that use of methods such as revealed preference to estimate the value of the good or service in question risks being

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[13] We presume a movement downwards of the MC curve for the sustainability equilibrium, which is consistent with the suggestion that the prices for produced capital goods will be lower relative to the environmental good price in the sustainable equilibrium than in the beggar-the-future (boom and bust) equilibrium. However, for any particular environmental good, this need not be the case; the point for present purposes is rather academic (see Muir & O'Connor [1994]).

[14] Correspondingly, the impression given of an acceptable "trade-off" of natural capital for produced capital while maintaining total capital stock intact, is systematically biased in favour of produced capital, which compromises the real achievement of the sustainability goals.

logically, as well as empirically, flawed unless specific steps are taken to ensure that the so-called demand curve properly reflects the "rights" structure presumed to underlie the reference equilibrium.[15]

In summary, we can construct several different versions of the allocatively efficient level of environmental capital use. Not all of them are consistent with sustainability norms. Some of different typical ethical premises might underpin advocacy of such norms, for example inter-temporal equity (hence willingness to bequeath) or respect of intrinsic/existence values.

3.2 Non-substitutability and the "strong sustainability criterion".

The reference to existence/intrinsic value introduces a particular type of non-substitutability, the rejection on ethical grounds of a trade-off between the environmental value in question and produced commodities (money goods) (see also Vadnjal & O'Connor [1994], Spash & Hanley [1994]). Ecologists and energy analysts during the past 25 years have also emphasised limits to the substitutability possibilities between natural and manufactured capitals, based on the special features of energy resources as necessary production inputs and of the biophysical milieu as a life-support service (see also Passet [1979]; Faucheux & Pillet [1994]). The presence of uncertainty and of irreversibility as regards natural system change, and also the functional multi-dimensionality of the environmental stocks, are further factors that mitigate against the assumption of substitutability.

The correct shadow price of these "critical" assets, whether based on irreversible loss of a stream of user values, or the marginal cost of attempted restoration, is then close to infinity. Several writers working in what we call the London School tradition have thus linked the notion of "critical natural capital" especially to functions for which currently there is little or no prospect of substitution -- the fundamental "life-support" functions of natural capital.

Pearce & Atkinson ([1993]), for exemple, have concluded that the "weak" sustainability rule is here of limited in applicability, and that the requirement is to set norms

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[15] The shadow prices of non-commodity natural capital may be based on individual preferences such as they are expressed for user value and option value only (estimation of Dp). They may alternatively be based on what Pearce & Turner [1990] term, the "total economic value" (actual use value + option value + existence value), assuming commensurability of the existence value with money. Evidently, neglect of existence value will lead to a lower estimate for the value of natural capital depreciation, by comparison with an approach including existence value -- and correspondingly to an "over-valuation" of the environmentally adjusted national income. We can ask ourselves the question whether the "rights of future generations" might be validly be considered under the heading Existence value rather than a User value. In this case, we have an alternative way of arriving at substantively the same sustainability norms. (For a detailed discussion on this theme, see Castells-Cabré, Froger & O'Connor [1994]).

defining the levels of stocks or functions to be maintained. In this respect, one can propose either : (1) that this critical natural capital be maintained constant in time (as do the advocates of the "steady state" such as Daly [1991]) ; or (2) that minimum safety levels be set (see Ciriacy-Wantrup [1952]; Bishop [1978]); or (3) as some London School writers have proposed (see Pearce [1976], [1988]), that sustainability threshold levels for critical natural capital use be defined, which in effect requires the elaboration of supplementary indicators for sustainability.

A "strong sustainability criterion" may be put forward according to which a minimum stock of natural capital should be preserved through time. That is:

$$\delta_n K_n \geq 0 \qquad (3)$$

These norms permit the measurement of the distances between the actual use levels of this capital (quantified in terms of environmental indicators) and the thresholds not to be crossed representing reference values set ex ante.[16] Having said all that, the London School analysts have, so far, made no workable propositions about a corrected aggregate monetary measure of capital stock value and its depreciation taking account of critical natural capital. This is one reason why, where monetary calculations are concerned, they usually end up keeping only the weak sustainability criterion. The measures of a "sustainable national income" (really ENIs) that they propose are therefore inherently limited. On the one hand, the various artifices employed for measuring the depreciation of natural capital are debatable on theoretical and empirical counts. On the other hand, the "weak" rule of sustainability premised on substitutability of natural capitals by produced capital does not reflect the normative imperatives of ecologically as well as economically sustainable development that are expressed in the intuitions underlying the "strong sustainability" perspective.

4. Corrected Aggregates as Measures of the Cost of Sustainability.

Several analysts (for example Hueting [1991]; Hueting, Bosch & de Boer [1992]), while not aligning themselves to the capital theory approach, have examined approaches to revision of systems of national accounts specifically to take account of ecological sustainability

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[16] The reference values may, in principle, be determined in terms of a past state of the environment, a desired future state, or criteria for a sustainable use of the environment.

concerns. They are not satisfied just to deduct from the GNP the value of asset depreciation. Rather, they set out to define preconditions for sustainability of all key environmental functions, as policy norms to be achieved, and then to obtain an estimate of the "sustainable national income" corresponding to achieving these norms. The Dutch Central Statistical Office, taking its inspiration from Hueting's work, proposes a methodology of this sort for correction of the GDP. In operational terms, the aim is to construct an indicator of the loss of environmental quality in monetary terms, to be comparable with the national income figures. We will summarise, first of all, the specific features of this approach that connect it back to a "strong criterion" perspective on economic-ecological sustainability (section 4.1). Then we will explain how the distinction should again be made between estimates of SNI and an ENI on the basis of "costs of achieving sustainability" (section 4.2).

4.1 "Strong" criteria for ecological-economic sustainability.

What we called -- in section 3 -- non-commodity natural capital, is typically characterised by multi-functionality of its elements. A single resource falling into this category might fulfill economic production input, recreational, biological, and pollution absorption functions. It is not possible to find substitutes for this ensemble of functions fulfilled by a given environmental asset. Nor can technological progress be considered to apply in any uniform way to these functions. From this point of view, a major part of non-commodity natural capital is critical natural capital, and so ought to be managed on the basis of defining maximum use thresholds.

Seen this way, the application of shadow scarcity rents as discussed earlier, is no longer adequate. On the one hand, having recourse to shadow prices comparable to market prices, which is the necessary precondition for determining any scarcity rent, runs up against some serious conceptual as well empirical difficulties. For example, as Hueting [1991] has discussed, the revealed preference method for estimating WTP measures runs into trouble when matters of life-support function are involved. On the other hand, and independently of the questions surrounding moral acceptability of the valuations obtained, such methods for valuation on-the-margin of natural capital depreciation lead, as we have shown in the preceding sections, to confounding an "economic optimum" (defined in terms of wealth-maximisation on an allocative efficiency basis) with a sustainable use of this capital. As we have seen (section 3.2), there is nothing in economic theory to suggest that an economic [Pareto-]optimum necessarily corresponds with maximum use thresholds for natural capital reflecting sustainable use norms. On the contrary, for valuations to reflect sustainability norms it would be necessary for the shadow prices to be obtained for a general equilibrium premised on a distribution of property rights supporting the defined sustainability and inter-temporal equity norms.

The cost-effectiveness methodology developed by Baumol & Oates [1971] offers one way of overcoming these difficulties. While initially elaborated in the context of pollution control, it is equally applicable to the management of natural resources, and thus applicable to "natural capital" more generally. In both cases, the idea is first to determine environmental standards or norms, for example, for pollution or consumption levels, in physical terms independently of any notion of economic optimisation; and then to find the least-economic-cost way of achieving the defined norm. A separation is thus maintained between ecological objectives as such, and the question of economic requirements for attaining them.

The propositions formulated by Hueting for "sustainable national income", rely on this logic of, first specifying sustainability norms to be attained, and, second, the economic costs of meeting them (see Hueting, Bosch & de Boer [1992]). In this framework, environmental goods and services are no longer considered in terms of natural capital, but rather as a collection of possible uses, or "environmental functions". This means the approach is not guided specifically by the Hicksian perspective on defining sustainability favoured by the capital theory analysts, although in their underlying thrust the two approaches are (as we will see in section 5.1) not inconsistent.

In cases where the use of one environmental function is at the expense of some other function, Hueting speaks of "competition between environmental functions". This is the case, for example, when productive uses of the environment impede its use for recreational purposes. This competition implies there will be some losses of environmental functions. So it is necessary to employ shadow prices in order to evaluate these losses in a way that allows them to be placed in comparison with the GDP expressed in terms of market prices.

Achieving this initial objective formally requires estimation of opportunity costs associated with degradation, or alternatively with protection or restoration, of environmental functions. This means effectively the identification of marginal costs and benefits. Rigorously, a comparative general equilibrium perspective could be adopted, but the conceptual, estimation, and computational requirements are quite great. So Hueting approaches the problem in a partial equilibrium perspective, that is, by reconsidering the old problem of the construction of supply and demand curves for the possible uses of the environment. A supply curve is obtainable, in principle, on the basis of estimates of the costs of the measures necessary for the restoration and/or preservation of the environmental functions. In other terms, it represents the portion of (say annual) costs borne by an economy in order to preserve a given range and level of environmental functions. On the other hand, the construction of a complete demand curve based on investigation of individual preferences, is a fairly impossible task, for the reasons indicated earlier (problem of weightings to future generations, unreliability of survey methods, difficulty of defining precisely the "goods" in question, WTP vs WTA, and so on). A practical solution is to replace the demand curve by a vertical line (inelastic with respect to price) which runs perpendicular to the environmental functions index along the horizontal axis -- see Graph 2 below. This vertical curve represents a norm signalling some socially decided choice for a sustainable use of the environment in question, for example respecting ecological limits such as assimilation and regeneration capacities (as non-substitutable functions).

Refer Graph 2 :

Conversion of physical costs into monetary costs.

On Graph 2, the marginal cost (supply) curve is labelled S; a possible "incomplete demand" curve relating to expressed individual preferences is labelled d; the pseudo-demand curve based on instituting a sustainability norm is labelled d'; and so quantity D where curve d' intersects the horizontal axis is the sustainable level of environmental use. If we suppose that B < D is the availability of environmental functions for the year under analysis, then BD is the distance, in physical terms, having to be crossed in order to reach a sustainable level or quality of environmental functions. Points E and F indicate the marginal preservation/restoration costs at actual (B) and sustainable (D) levels of environmental use; and the area vertically under the marginal restoration/preservation cost between B and D (that is, integrating under the relevant portion of the supply curve), call it area BEFD, represents the "cost of achieving sustainability" for these environmental functions.[17]

The overall procedure is therefore as follows. First, physical norms are defined for environmental functions based on some assessment of their sustainable use level (here represented by point D). Second, in order to satisfy these norms, meaning moving from the present situation B to the level D, remedial measures are required. Hueting proposes the following four categories:

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[17] In the exposition of Hueting's method, it seems to have become widespread to assert that the distance EF measures the cost of adjustment (see for example Figure 1 in Hueting, Bosch & de Boer [1992, p.8]. But if the diagram depicts a marginal cost (= "supply") curve, then the vertical distance EF doesn't represent anything in particular; and as we describe, it is the integral under the relevant portion of this mc curve that represents the estimate that we want. It is also worth noting that a "money estimate" of the present-day loss of environmental functions relative to the sustainability norm, is the area under the d-curve between B and D, which by construction is less than the "costs of achieving sustainability".

-- measures of a technical sort, such as improved pollution abatement within existing plant;

-- incentives for the exploitation of renewable resources as alternatives to non-renewable resources;

-- measures aimed at replacing noxious activities by alternatives that are not dangerous to the environment;

-- measures to reduce the volume of real economic activity (through achieving reduced materials and energy throughputs).

Estimates are then made of the money amounts that would be needed to implement such measures. Working this way, the losses measured in physical terms for the year are translated into monetary terms. For each environmental function needing protection/restoration, the valuation corresponds to the minimum cost to be borne in order to move from the current situation to a sustainable use level (that is, from B to D). In effect, this constitutes an estimate of the opportunity cost in terms of consumption (economic output valued in present prices) that would have to be foregone to achieve the specified environmental norms.

Hueting then goes a step further in proposing that the whole set of such costs, say CAS, ought then to be deducted from the conventional net national product (or, equivalently for our exposition purposes, net domestic product, designated Y). He suggests that this procedure yields an estimate of sustainable national income (say designated Y*):

$$Y^* = Y - CAS \qquad (4)$$

In fact, while we can call this an ENI, equation *(4)* does not constitute a definition of a "sustainable national income", and it may not be a good approximation either, for reasons that we will discuss in section 4.2.

4.2 Costs of achieving sustainability versus sustainable national income.

Hueting's procedure, while far from being theoretically pure, seems a reasonable rough and ready method for getting a feel of the performance and potential of a national economy in relation to sustainability goals. In particular, this way of constructing an ENI corresponds well to the "strong criterion" of ecological-economic sustainability. Hueting's method builds in the idea of respect of critical use level thresholds for sustainability of environmental functions, in effect defining norms for the preservation of environmental functions for future generations.

However, this procedure for "correcting" the traditional national income should not be described as a method for defining and obtaining an estimate for a sustainable national income (SNI). As Hueting himself has noted (Hueting [1991]), the adjustment costs are estimated as a summation of the costs associated with achieving the norm for each environmental function, with the estimates/calculations being made separately on the basis of market prices. It is intuitively obvious that, cumulatively, the hypothetical adjustments involve very major changes in economic structure (and, therefore, relative prices, etc.). So the ceteris paribus assumptions of the partial equilibrium cost-estimation methods are unsatisfactory. The supply and demand curves will "shift around".

In effect, in describing Y* as a "sustainable national income," two distinct reference systems are being mixed together. On the one hand, all of the estimates of adjustment costs, the actual GDP and NDP figures for current economic activity, and hence the "corrected" national income figure (ENI) thus derived -- are calculated using market prices that relate to a structure of economic activity that is, by hypothesis, contrary to sustainability norms. On the other hand, the rigorous definition of a long-run "sustainable national income" (SNI) refers, as we have said, to the national income generated along a sustainable equilibrium time-path, with the capitals valued with the prices associated with this equilibrium.

Let us suppose for discussion purposes, that this hypothetical sustainable path is coincident with the environmental norms utilised in an application of Hueting's procedure. It is easy to see that the measure for Y* (= an ENI) obtained in the above equation *(4)* "correction" procedure is not in any way an reliable estimate of the feasible "sustainable national income" (a SNI, hopefully > 0) for the economy.

For instance, one conceivable outcome is that Hueting's method might lead to estimation of total costs of adjustment (opportunity costs of achieving sustainability norms) exceeding the uncorrected NDP. Such a result would seem to imply that indeed the economy is running down its capital. The conclusion is that in the situation being measured, the society has the choice between (i) depleting/degrading environmental capital by not making the adjustments required to satisfy the norms; (ii) or depleting/decumulating economic capital if it accepts to make the resource commitments for the adjustments really are made. Now, it is quite conceivable that one obtains a negative Y* with Hueting's method, while nonetheless being able to identify a positive SNI based on radical economic restructuring and technology changes (with attendant changes in relative prices, etc.). The two measures are fundamentally distinct.[18]

We conclude that Hueting's method for calculating opportunity costs for respecting sustainability norms, leading to estimation of a Y* in equation *(4)*, gives a valid and useful indicator of the "costs of achieving sustainability" both in terms of the magnitude of the expenditures required (measured in current prices) and also in terms of the burden this adjustment will place on natural and/or economic capital stocks. However it would be dangerous to use the Y* as a proxy for estimating the size or sign of a feasible long-run "sustainable national income" (SNI), as this Y* is likely (we think) to be systematically too low. The use of the terminology "sustainable national income" is, in the context of Hueting's method, misplaced. More theoretical and empirical estimation work is required to clarify the significance of this point as a lot will depend on the nature of assumptions made about technological change possibilities and lifestyle options.

5. Concluding Discussion

Three points deserve special emphasis by way of conclusions. First, in our view, the propositions for revision of the system of national accounts emerging respectively from the capital theory perspective and Hueting's methodology may be understood complementary in character (section 5.1). Second, we should point out the difficulty of implementing a "normative" framework because of the scientific uncertainties and distributional conflicts inherent in setting sustainability objectives (section 5.2). Third, we emphasise the importance of the distinction between ENI and SNI (section 5.3) in design and implementation of sustainability policy.

5.1 Complementarity of Weak and Strong Criteria.

In contrast to the "weak sustainability" approaches reviewed in section 3, the Hueting methodology seeks explicitly to respond to the normative choices of "sustainable development". The specific objective of ecological sustainability is typically expressed in terms of three sorts of constraints to be imposed on economic growth paths (Barbier &

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18 This distinction seems to be clearly embodied in the recent, as yet unpublished work by de Boer et alii [1994].

Markandya [1990]). The first stipulates that the utilisation of renewable resources should not exceed their rate of renewal; the second that waste emissions should be less than the assimilation capacity of the environment; the third that exhaustible resources should be extracted at such a rate as permits their replacement by renewable sources.

Hueting's approach, while crude in its valuation methodology for the reasons mentioned above, nonetheless seems adequate as a way of addressing the first and second of these constraints, and for evaluating the depreciation of non-commodity natural capital in the sense of multi-functional environmental assets (renewable natural resources and systems such as air, water, forests and soils). This leaves the question of what constitutes an adequate treatment of commodity natural capital, or single-function environmental assets, in particular of depletable resources such as oil, coal, copper. Within the framework of capital theory, one can propose that their value be assessed in terms of opportunity cost, and this valuation then be compared with marginal extraction costs. In theory, the scarcity rent which is the difference between these two figures, should constitute an acceptable indicator of the increasing scarcity of the resource. Where the natural assets in question have only a single economic function, typically as production inputs, the considerations about strictly limited possibilities of substitution and limits to technological progress that apply to multi-function natural capital, are less crucial. Assuming that appropriate property rights are specified and given effect (relating notably to the interests of future generations), the market may be considered an adequate allocative mechanism for such capital without the need for externally imposed environmental norms. One might also propose that, if the market works perfectly in signalling incentives to profit-maximising agents, the rise in prices over time will ensure technological progress improving efficiency of use of these assets as well as the substitution of exhaustible natural resources by renewable resources and manufactured capital. Under these assumptions, the requirements of the third sustainability constraint stated above are "automatically" satisfied. One can thus be persuaded that, in theory, scarcity rent is satisfactory as a measure for the depletion of single-function commodity natural capital.

Therefore it seems to us that, formally, a complementarity exists between the method put forward by the "weak sustainability" proponents in application to single-function environmental assets (especially non renewable ones), and that of Hueting relating to multi-function non-substituable assets and ecosystems, for determining a corrected aggregate consistent with the strong sustainability ideal. The following definition of an "environmentally adjusted national income" (ENI) can therefore be proposed:

$$Y^* = Y - Rep - C_{nr} - C_{na}, \text{ where} \qquad (5)$$

Y is the net national product (NNP = GNP minus the depreciation of manufactured capital);

Rep is the aggregated scarcity rent for depletable resources;

C_{nr} is the cost of reaching the sustainability norm for renewable resources (that is, use levels respecting their rate of renewal);

C_{na} is the cost of achieving the sustainability norm for waste discharges and disruptions to life-support functions, that is, respecting the assimilation capacities of the environment.

In practice, however, things are much less straightforward. First of all, the validity of the scarcity rent indicator for single-function commodity natural capitals is conditional on getting the (shadow) price right, and depends also on abstracting away from -- or coherently taking into account -- uncertainty relating to costs and new discoveries. It may plausibly be argued that since the economy as a whole is, prima facie, operating far from overall allocative efficiency due to the prevalence of oligopoly power and unpriced scarce environmental services; we are in a situation of "second best," and care must be taken about the interpretation of opportunity costs and benefits evaluated with market prices. In particular, given the the biases inherent in prevailing market structures (market power, high commercial discount rates, strategic behaviour), which together imply a strong status quo bias in favour of the present over the future, not too much confidence can be placed in market prices as a reasonable approximation to inter-temporal opportunity costs of natural resource use (see Norgaard [1990]).

Moreover, even if something approaching a correct shadow price path were estimated for the value of depletable resources in an inter-temporal use perspective, there are further reasons why these prices may still not be compatible with the sustainability norm. First, there may be significant "externalities" associated with the extraction and use of the resource (habitat and other environmental disruptions relating to extraction, negative externalities of techno-industrial structures, waste disposal problems) that are not internalised in the resource rents. If these external effects relate to so-called multi-function environmental capitals (ecological vitality, life support systems, cultures' heritages and amenity interests, etc.), then it would become necessary to have recourse to the methods appropriate to such capitals, namely choosing norms and estimating costs of adjustment. Second, even if indeed it is supposed that the economy is somewhere near an allocatively efficient general equilibrium (as is required for the validity of partial equilibrium methods of estimating scarcity rents), this equilibrium is likely to reflect the structure of privileged access to natural resources and environmental services enjoyed by present generations relative to future generations. For the scarcity rents to reflect a sustainability norm, it would be required that the market mechanism be operating on the platform of a property rights (and obligations of respect) structure compatible with inter-generational fairness of opportunity. This is prima facie not the case. While some countries have expressed policy goals to this effect, or even implemented laws enshrining respect for the "needs of future generations" as a legal requirement (e.g. in New Zealand, see Arnoux et alii [1993]; Memon [1993]), the real workings of markets are far removed from this requirement.

5.2. Procedural difficulties with the "environmental norms" approach.

With regard to multi-function (and typically non-commodified) natural capitals, there are also some distinctive difficulties in practice. These relate particularly to the setting of norms and standards to ensure ecological sustainability and to provide for renewable resource use within limits of regeneration capacity. The determination of appropriate standards may seem largely a matter of scientific research and its application. However, there are irreducible social and political dimensions as well. There are also difficulties with aggregation of different sorts of physical quantities and properties expressed in a variety of units. For example, if emissions of CO_2 diminish while those of SO_2 rise, how can one decide whether the state of the environment has improved, got worse, or stayed the same?

On the one hand, as we have seen, these norms cannot be set through use of conventional economic valuation methods. On the other hand, scientific analyses are not sufficient to determine them without ambiguity, because most environmental problems are characterised by a fluid and incomplete state of scientific knowledge, accompanied by the inherent unpredictabilities of complex systems and because in any case there is the problem of social distribution of risks, benefits, costs, and opportunities. Even if the scientific basis were clearcut, there is no guarantee that norms proposed on that basis would always be socially acceptable. And it is obvious that without a strong social commitment, there is no way that respect of principles of ecological sustainability can be assured. This is the reason why, ideally, the environmental standards ought to be arrived at through a public participation process involving a wide range of social interests. The decision process would thus conform to a sort of procedural rationality, taking place through an iterative process of trade-offs and compromises with multiple criteria, with the aim of ending up with a solution that is satisfactory in terms of economic, social, and ecological imperatives (Faucheux, Froger & Noèl [1993]; Faucheux, Froger & Munda [1994]). In practice, just as with the problems relating to specification of a demand function for environmental quality and to the specification of a time-discount rate (relating to individual time-preference and obligations to future generations), the selection of the levels of environmental functions "desired" or to be "sustained" amounts to a choice process that is essentially political rather than technical in nature (see Castells-Cabré, Froger & O'Connor [1994]).[19]

Sustainable environmental management involves making choices as to the particular ecosystems, species habitats, heritage values, community structures, etc., that are to be respected and provided for. Social groups differentiated by place, time, cultural heritage, collective identity, life experience and hence "preferences," will have widely divergent priorities. So allocative efficiency criteria are strictly secondary in importance, as the main decisions are distributional ones. Sustainability policy therefore has to address and resolve two layers of distributional questions : What is, will be, or should be the distribution of welfare, that is, of wealth, of political and economic rights, of economic opportunity, and of access to environmental benefits and amenities: (1) within each generation now, and (2) into the future? The thing that matters is: costs for whom, benefits for whom, when and where? In other words, whose interests are to count? And this entails the procedural problem: How do we choose amongst the various particular economic and ecological outcomes that might be feasible within the framework of long-term sustainable activity? Effective sustainability policy depends on putting in place political/communal processes for deciding on the "mix" of economic, community, and environmental purposes to be pursued. This is what the setting of ecological norms means in practice.

5.3. Opportunity costs and sustainable national income.

The "weak version" derived from the neoclassical capital theory, presuming a substitutability between the different categories of capital, promulgate a notion of sustainability that is essentially "economic" in character: sustaining, or increase through time of, the value of agregate capital stock. In accounting terms, the question of sustainability is thus addressed through substracting the depreciations of both manufactured and natural capitals from the conventional GNP. The work by Hueting and those following him, by contrast, is motivated by a more "ecological-economic" concept of sustainability where the maintenance or renewal of a plurality of ecological systems and functions is explicitly sought after. Translated into accounting terms, sustainability is addressed in terms of the costs to be borne in achieving the sustainability norms (or the steps along the way) specified ex ante.

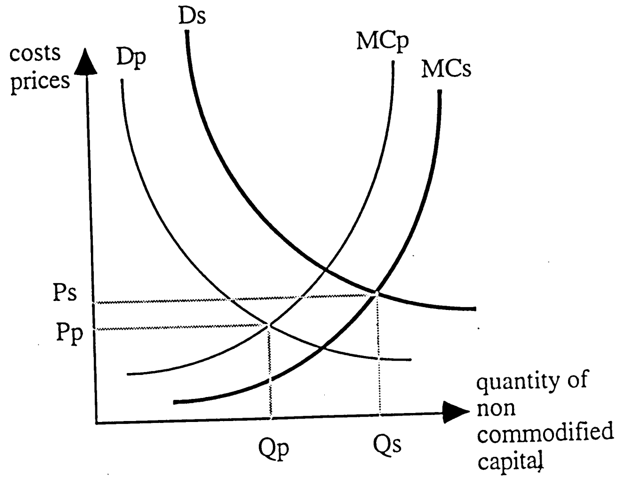
But irrespective the exact method by which the "environmentally corrected national income" (ENI) is obtained, the point remains that this measure does not in itself constitute an

[19] This procedural dimension of environmental decisionmaking is dealt with in depth by the DG-XII funded research project on "Non-Monetary Indicators for a Sustainable Development" led by the C3E.

indicator of the sustainable development potential of the economy/environment in question. The "environmentally corrected national income" figures are obtained by subtracting the "costs of respecting sustainability norms" (consumption forgone or scarcity rents paid, etc.) from the traditionally defined net national product. An ENI is thus based on measures of income in current prices, and of opportunity costs associated with preserving capital stocks also in current prices or shadow prices relating to the status quo. This adjustment cost figure (CAS) is thus an indicator of the distance or difference between the present situation (as indicated by the traditional measures of gross and net national product) and a hypothetical reference state (a postulated sustainable situation).[20] It is the "cost of sustainability", in the "weak" sense inasmuch as the corrections are made within the framework of capital theory on premises of substitutability, and in the "strong" sense if following Hueting's method based on setting ecological norms.

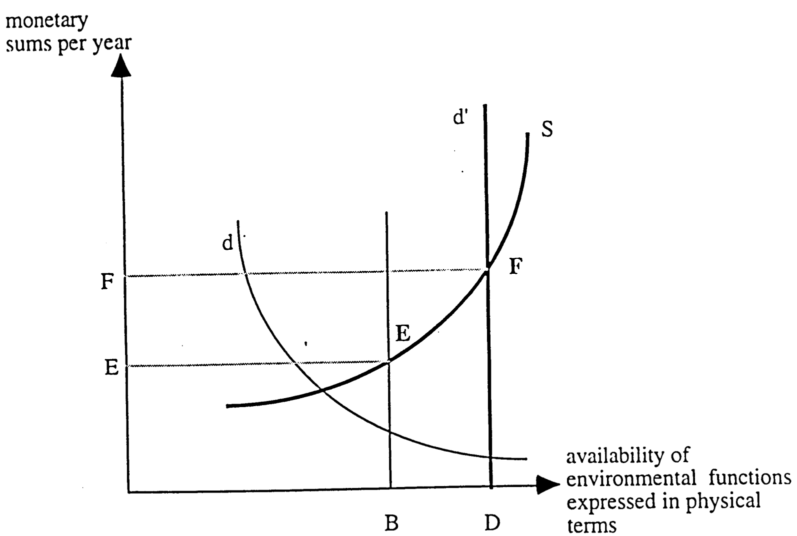
Either way, a CAS measure does not constitute the basis for estimating a "sustainable national income" (SNI) as such. A measure of the latter would relate to what is or might be feasible as national consumption if the economy were actually moving along a sustainable devlopment path (de Boer et alii [1994]). It will be useful therefore to undertake theoretical and empirical work aimed at two distinct outputs: (i) the order of magnitude of a SNI, and (ii) the costs of getting onto a sustainable path. In this context we should note the likelihood that, for many countries, this might require a transition path where for several years the ENI (Y* = Y - CAS) is negative, in order to arrive at a sustainable pattern of activity where the SNI is positive. Conceptual and empirical estimation work should proceed on the basis of clarifying the distinction between these two concepts, and also the relationships between them as complementary policy reference points.

[20] This concept of "cost of attaining sustainability" could be broadened out to a way of estimating costs of taking defined steps on a pro-sustainability transition path in a given year.



Graph 1 :

Depreciation of non commodified natural capital



Graph 2 :

Conversion of physical costs into monetary costs.

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