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Whither economics? From optimality to sustainability?*

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ABSTRACT. Environment and economy interact. Most economists and economic policy makers have tended to neglect this interaction as 'external' to mainstream market economics. The question is whether environmental externalities have reached a level where they overwhelm optimality and efficiency in resource allocation. Sustainability in growth and development has been advanced as a criterion for dealing with the social costs of environmental impacts. The article examines how this criterion can be operationalized for assessing the significance of environmental concerns in economic analysis and policy. Indicators of economic and ecological sustainability are defined and compiled for selected countries. Based on these indicators, operational paradigms of 'eco-nomics' and 'sustainable development' are advanced.

1. Economics out of sync?

Bashing economics for wrong diagnoses and misleading policy advice has a tradition. The oil crises of the 1970s, social upheaval following structural adjustment in developing countries, the chaotic transition from centrally planned to market economies, and conspicuous environmental externalities cast doubt on the predictive and advisory capability of conventional analysis. Perhaps the most eloquent critique of one of the basic tenets of economics, namely, optimal resource use under ideal conditions of atomistic markets, was launched by Galbraith (1986).[1] More recently, as part of a growing literature of 'discontent', the apparent resurgence of *laissez-faire* economics has been castigated on account of its indifference to reality: for-

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[1] It is quite curious that Galbraith's attack on the fundamentals of widely taught and applied economics has brought about so little change in economic analysis. Galbraith (1986) himself points out that this is due to an alliance of 'mature' corporations and the state; both hide their common goals of economic growth and power behind the screen of allegiance to—powerless—perfect competition.

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malistic rigour appears to be favoured at the expense of real-world vision (Ehrlich, 1994; Heilbroner and Milberg, 1995; Kuttner, 1997).

Mainstream economists seem to ignore or deny the mounting critique of economic fundamentals, in particular of 'rational' microeconomic behaviour in perfectly competitive markets, ensuring optimality in the allocation of scarce resources. Others argue that action based on an ideal situation might contribute to achieving this situation, possibly by a 'sequence of policy reforms' (Dasgupta, 1994: 42), or that 'economics in a vacuum' might still throw light on complicated problems (Samuelson and Nordhaus, 1992: 295). As long as nothing drastic happens, we can probably live with the 'semi-fiction' (Solow, 1992: 10) of perfect markets.

At the same time, drastic things do happen. Environmental phenomena that were characteristically dismissed as 'external' to market economics may have reached a scale where they undermine policy analysis based on conventional economics by generating 'social' costs in excess of 'private' benefits of income and consumption. A frequently cited example is the case of Kiribati, a Pacific Ocean island living off its phosphate deposits. Depletion of these deposits terminated all mining activities in 1982, and GDP dropped to less than half of its average level of the previous four years (OECD, 1985). Dismissing this issue as the concern of a small island will not do either. Industrialized countries may have dumped a good deal of increasing environmental problems on financially starved developing countries. Importing natural resources (e.g. of fish and timber) and translocating unsafe and polluting industries can be seen as the export of depletion and degradation to the 'Third World' under the cloak of market liberalization.

Other, notably global, phenomena such as climate change, ozone holes, land degradation and species extinction appear to 'swamp economic values in a sea of externalities', rendering economics 'useless' for dealing with these phenomena (Martinez-Alier, 1987: xii, xiv). As one of the leading green economists puts it, the planetary boat might sink if overloaded by pollution and depletion, however optimal the distribution of its load (Daly, 1989). This picture conveys the impression that economics of optimal resource allocation has become irrelevant as it is overridden by the transgression of vital environmental limits.

If environmental phenomena were independent of economic activity, there would be no need to trouble economic analysis. Environmental issues could be addressed by environmental policies, and economics could pursue its own objectives without risk of impairing the achievement of its own and other domains' objectives. Environment and economy interact, however. Policy failures in both environment and development have been traced back to the neglect of this interdependence by compartmentalized line ministries and agencies (WCED, 1987).

Much of the discussion of the relevance of environmental phenomena for economic performance and development is still unsubstantiated, however. How close are we to life-threatening environmental limits? Is the planetary boat sinking? Does the economic system head for self-destruction as it undermines its environmental support systems (Brown *et al.*, 1993)? Is sustainable growth just a bad oxymoron (Daly, 1991), or a *sine qua non* for development (Boutros-Ghali, 1995)?

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In support of the non-sustainability of current patterns of production, consumption and economic growth, reference is typically made to[2]

- *climate change*: 1–3.5°C global warming, caused by greenhouse gas emissions (1995 assessment by the Intergovernmental Panel on Climate Change);
- *biomass appropriation*: 40 per cent of annual net primary productivity used up by consumption of organic material and destructive land use (Vitousek *et al*., 1986);
- *ozone layer depletion*: ozone layer in 1993 at an all-time low of 90 Dobson units, with the ozone hole 15 per cent larger than in previous years (Brown *et al*., 1994), caused by the use of CFCs and halons in refrigeration, insulation and packaging;
- *land degradation and desertification*: 500 billion tons of top soil lost since 1972 (Brown *et al*., 1993); 5 million hectares lost annually to desertification;
- *biodiversity*: one-quarter of species in danger of extinction; 5,000 to 150,000 species lost annually, caused by destruction of biomes and habitat by agriculture, deforestation, pollution and other land uses;
- *deforestation*: 16.8 million hectares lost annually from logging and land clearance for agriculture and settlement;
- *energy*: 90 years of proved recoverable (mineral) reserves, 243 years of proved reserves in place, and 800 years of total (including additional estimated) reserves left (United Nations, 1992).

Obviously, answers cannot be found by simply listing disparate indicators, expressed in so many degrees of global warming, Dobson units of ozone depletion or hectares of advancing deserts. An operational definition of sustainability is needed, capable of combining or comparing all these phenomena, among each other and with the costs and benefits of related economic activities. This article explores the possibilities of quantifying environment–economy interaction by means of comparable (integrative) measures, uses the underlying concepts for operational definitions of sustainability in growth and development, presents first statistical results, and reaches conclusions on the relevance of mainstream economic analysis and on the need to introduce new paradigms.

2. Operationalizing sustainability: a dichotomy of approaches

To achieve integration of environmental concerns and economic objectives, both 'economists' and 'environmentalists'[3] looked into their

[2] Where not otherwise specified, the source is UNEP (1992).

[3] To use a crude distinction, for purposes of exposition, between advocates of mainsteam neoclassical economics and advocates of holistic views of the human environment. The latter views have been expressed in particular by 'deep ecologists' who emphasize the need for a comprehensive, religious and philosophical world-view and the intrinsic equality of all species (Naess, 1976; Devall and Sessions, 1985). In a similar vein, reference is made to 'environmental economists'. Of course, neither the existing schools of thought nor their representatives may fully fit into this simplified categorization.

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analytical toolkits so as to apply them to the other field. In doing so, they imposed their own values, with the result of distinctly different views of sustainability in growth and development.

Environmental economists thus seek to incorporate scarce environmental goods and services into their economic (monetary) value system. Their premise is that the environment can be treated as a commodity because this is how individuals perceive it. Consumers can therefore be prompted to reveal their preferences for environmental services or dispreferences for service losses in money terms. In the absence of markets, supply and demand curves for this classical public good can at least be imagined, if not simulated.

To this end, the concept of economic value is broadened to include the use of natural resources and environmental functions of waste absorption, as well as the non-use values, i.e. option or existence values, derived from the knowledge about preserved ecosystems or species (Munasinghe, 1993). A variety of valuation techniques to capture these values have been developed for cost–benefit analyses of the environmental impacts of projects and programmes. Several of these valuations were incorporated in methodologies of 'green' national accounting (Bartelmus, 1997). Some environmental economists go further into 'analysis', advocating the introduction of—shadow-priced—environmental welfare effects into national income or net national product (Mäler, 1991; Pearce, 1994).

Environmentalists contest the notion that the environment can be treated as a commodity. People see, or should see, the environment from a cultural or ethical point of view as an indivisible social good. Toward such a good, people express attitudes or moral convictions (see, e.g., Doob, 1995) rather than preferences in terms of economic costs and benefits. It is repugnant to see the value of a public good or national heritage subjected to the 'willingness to pay' which in reality might reflect an 'ability to pay' (Jacobs, 1994: 80). The question is not how to generate economic value for an underpriced commodity, but how to prevent being 'colonized by the economy' through misleading economic valuation (van Dieren, 1995: 7).

Since, according to this reasoning, the real value of nature cannot be expressed in monetary terms, new indicators or indices of the 'quality of life' (OECD, 1973), 'human development' (UNDP, 1995) or 'sustainable development' have been advanced.[4] Aggregation of the different facets of these concepts would have to be done by appropriate weighting of the quantifiable aspects of priority concerns and/or related activities and results. Such indicator selection and weighting bears the risk of representing the values and parameters of the index-builders and might thus reflect the priorities of environmentalist mindsets, preferences and data frameworks—colonizing the economy?

The result is a distinct dichotomy in measuring and analysing the interactions between environment, economic performance, growth and development. The dichotomy is based on two different 'world-views' of the role of the natural environment in human life. They can be broadly

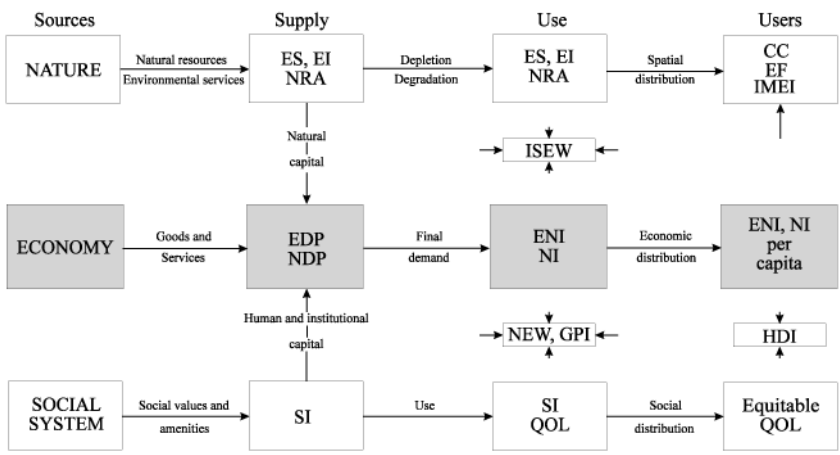
[4] See, for a brief literature review of quality-of-life indicators, Fergany (1994); an overview of indicators of sustainable development is given by Bartelmus (1994b).

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characterized as the advocacy of (1) *economic sustainability*, aiming at the long-term preservation of economic output, income or consumption, i.e. economic growth, and (2) *ecological sustainability*, focusing on the preservation of human populations in a given territory, endowed with limited natural assets. Ecological sustainability represents an application of the ecological concepts of carrying capacity and optimum sustained yield of bioproductive systems (Odum, 1971) to the general use of nature by humans, notably for life support. Economic sustainability is production- and consumption-oriented, while ecological sustainability is focused directly on people and their needs. As a consequence, the role of the environment is differently perceived, either as a requisite for economic growth or as the provider of essential consumer services or amenities.

Figure 1 presents this dichotomy between economic values and measures (in shaded boxes) and physical or non-monetary concepts and measures (in white boxes). Use is made of a generic process of supply, use and users of goods, services and amenities from nature, the economy and the social system. This presentation permits the further categorization of sustainability of supply, use and users, and a possible distinction between the sustainability of economic (supply and use) and human (users/populations) development. The distinction is a useful reminder that the ultimate objective of sustainability is, not human activity, but human beings themselves.

Monetary measures in Figure 1 include those compiled in extended national accounts such as the United Nations (1993a) system of integrated environmental and economic accounting (SEEA). These measures are de-



Explanations: → flows of goods, services and amenities.

Acronyms:

CC	Carrying capacity	IMEI	Index of Material/Energy Intensity
EDP	Environmentally adjusted net Domestic Product	ISEW	Index of Sustainable Economic Welfare
EF	Ecological Footprint	NDP	Net Domestic Product
EI	Environmental Indicators	NEW	Net Economic Welfare
ENI	Environmentally-adjusted National Income	NI	National Income
ES	Environmental Statistics	NRA	Natural Resource Accounts (aggregates)
GPI	Genuine Progress Indicator	QOL	Quality of Life (indicators)
HDI	Human Development Index	SI	Social Indicators

Source: Bartelmus 1994a.

Figure 1. *Sustainability concepts and measures.*

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rived indeed by imposing monetary values on environmental concerns. As a result, conventional economic indicators such as national income and product, capital, investment, saving or consumption are modified to obtain 'green' aggregates, in particular an environmentally adjusted net domestic product (EDP; see section 3). Non-monetary measures of ecological sustainability include the carrying capacity (CC) of a territory, which measures the sustainability of human populations in a particular geographic area, and its inverse, the ecological footprint (EF), which measures the land area affected by an inhabited area beyond immediate occupation (Rees and Wackernagel, 1994). Further attempts at capturing ecological sustainability include the development of frameworks or lists of social and environmental indicators (SI, EI), possibly combined into indicators of sustainable development, and the above-mentioned indices of the quality of life (QOL) or human development (HDI).

The capability of both monetary and physical indicators to measure significant aspects of economic and ecological sustainability is explored in the following sections. Other proposals attempt to measure the basically non-operational generic notion of sustainability, defined as non-declining welfare (Pezzey, 1989), by adding 'desirables' to and deducting 'regrettables' from per capita national income or consumption. These indices are typically compiled outside a systematic framework and suffer from lack of transparency in index composition and compilation, and arbitrariness in scope, coverage, weighting and valuation; they are therefore not further discussed here.[5]

3. Measuring economic sustainability

Economic theory and accounting already use a narrowly defined 'sustainability' criterion when considering the depreciation or consumption of *produced* capital. The rationale is to distinguish clearly between income and capital to avoid consuming the capital base of income generation.[6] The use of financial or produced capital for consumption, without replacement or reproduction is clearly non-sustainable in the long term. Focusing on produced capital, the—national—accounting argument is more neutral in justifying the netting-out of 'capital consumption'. It refers to the need to avoid double-counting in the aggregation of economic output: the inputs of produced goods and services, including capital services (reflected in the

[5] Figure 1 displays some of the better-known indices in between the physical and monetary data streams, notably the measure of net economic welfare (NEW; Samuelson and Nordhaus, 1992), the Index of Sustainable Economic Welfare (ISEW; Daly and Cobb, 1989), and the ISEW-based Genuine Progress Indicator (GPI; Cobb *et al*., 1995).

[6] This time-honoured distinction can be traced back to Adam Smith (1776, cited by El Serafy, 1989) who advanced the notion of 'neat revenue' which can be consumed by the inhabitants of a country 'without encroaching upon their capital'. This concept was restated 160 years later by Hicks (1946: 172) as a 'guide for prudent conduct ... to give people an indication of how much they can consume without impoverishing themselves'. Similarly, national (disposable) income can be distinguished from 'net worth' in national accounts conventions with certain assumptions about the composition of net worth (see CEC *et al*., 1993, para. 8.15).

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'wear and tear' of capital goods), are deducted from gross output to obtain net value added and its sum total, net domestic product (NDP).

By opening the asset boundary of national accounts to non-produced natural assets, the SEEA makes use of Hicks's prudency argument (see note 6). The costing of natural resource inputs and waste absorption services is justified by their scarcity and necessity for production. Using the extended national accounts concepts, the sustainability of economic performance can now be operationally defined as the maintenance of produced *and* natural capital, used in the production of goods and services. More comprehensive analyses of the sustainability of production and growth would have to take into account further factors of production, i.e. human and institutional capital, as well as effects of technological progress, substitution among production factors and material inputs, changes in consumption patterns, and impacts of natural disasters.

Setting aside the difficult-to-measure human and institutional capital and the erratic impacts of catastrophes, the question remains *how much* capital maintenance is needed, given the possibilities of substituting scarce natural capital by applying environmentally sound, clean and resource-saving production and consumption techniques. 'Weak sustainability' would assume that scarce natural assets can be replaced by other production factors, and overall (total) capital maintenance is a sufficient measure of sustainability. Complementarities in natural asset use would require 'strong sustainability', i.e. the full conservation of natural capital categories. 'Sensible sustainability' has been advocated as a criterion that takes both complementarity and substitution possibilities into account (Serageldin and Steer, 1994).

The different 'strengths' of sustainability are reflected to some degree in the green accounting aggregates calculated according to different valuation methods. Three basic valuations are proposed by the SEEA. They are (1) market valuation of economic natural assets and their changes, (2) maintenance costing of environmental degradation and destruction, and (3) contingent valuation of damage resulting from degradation and destruction.

Market valuation is applied to 'economic (natural) assets', whose extraction or harvest yields economic gains (CEC *et al.*, 1993, para. 10.2). Market valuation focuses therefore on the income generation capacity of natural assets whose products of minerals, fish or timber are sold in the market. Discounting the value of expected net revenues obtains a market value of the natural assets and their consumption. From a microeconomic point of view, the change in economic value of a reproducible or renewable (natural) asset calls for making a cost allowance that permits the replacement of the asset at its market value.[7] This is a strong-sustainability criterion, as it refers to the income generation capacity of the particular

[7] Under certain conditions (perfect competition, optimal resource use, full substitutability of production factors), the net rent per unit, i.e. the 'net price', can be used as a proxy for obtaining the change-in-present-value depreciation cost. See, for a discussion of the underlying assumptions in this case, and also of other valuation methods, Bartelmus (1997).

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natural asset only. An alternative is the 'user cost allowance' (El Serafy, 1989) which retains only part of the net income generated from the sale of asset outputs. It aims at a permanent income stream from investing this allowance in any kind of production activity or even financial markets. Clearly the objective of income maintenance reflects a weak-sustainability concept, without regard to the future composition of capital at the micro- or macroeconomic levels.

Maintenance valuation is introduced in the SEEA in order to cost environmental externalities in addition to the depletion of natural resources. Focusing only on 'economic' assets (in the SNA sense) would be a radical reduction of economic analysis, excluding scarce resources only because they are not traded in markets.[8] Environmental maintenance costs are defined as the costs that one would have had to incur in order to avoid the deterioration of the environment by current production and consumption activities (during the accounting period). These costs are similar to depreciation allowances made to replace worn-out fixed capital; they are the costs required to maintain environmental sink and (re)source capacities. This is a strong-sustainability concept calling for the full conservation of an environmental asset. The justification is that uncertainty about possible long-term hazards and irreversibilities of environmental impacts may indeed call for a high degree of risk aversion, i.e. the maintenance of at least the present level of environmental quality in most cases (United Nations, 1993a, para. 53). In other cases, compliance with appropriate emission standards would have to be costed, allowing for safe uses of environmental capacities.

C*ontingent valuation* is hardly applicable in routine—national—accounting, from both a data availability and a theoretical[9] point of view. On the other hand, it could be used for estimating demand for particular environmental protection programmes, based on the revealed dispreferences for environmental damage. In theory, acceptance of compensation for environmental damage could be interpreted as weak sustainability of welfare generation in terms of income maintenance, while the willingness to pay for conservation of particular environmental assets would point to a preference for strong sustainability or full conservation of these assets.

In practice, i.e. in country projects implementing the SEEA, for market valuation the simpler 'net price method' has been generally applied, either alone or in combination with maintenance costing. The result is the compilation of two environmentally adjusted indicators of overall economic performance: EDP1, representing strong sustainability of economic assets, and EDP2, representing strong sustainability of both economic and environmental assets.

[8] Indeed, the SNA itself introduces public goods production and consumption with the argument of 'market failure' (CEC *et al*., 1993, paras. 9.84, 9.92). This is clearly a value judgment about what *should* be included in the accounting system. It seems to be a small step from here to argue the inclusion of another public good, the environment, at least in 'satellites' of the core accounts, even if the scarce environmental services are offered by nature rather than a social institution.

[9] Contingent valuation which includes consumer surplus when assessing the willingness to pay for a particular good or service is inconsistent with the market price valuation applied to economic 'transactions' in national accounts.

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Table 1. *Net domestic product (NDP) and environmentally adjusted net domestic product (EDP) in case-studies of green accounting (lowest and highest percentages)*

Country	*EDP1*[a]*/NDP(%)*	*EDP2*[b]*/NDP(%)*
Costa Rica (1970–89)[c]	89–96	
Mexico (1985)	94	87
Indonesia (1971–84)[c]	69–87	
Japan (1985 / 90)	98 / 99.6	97 / 98
Korea, Republic of (1985–92)[d]	100	96–98
Papua New Guinea (1986–90)	92–99	90–97
Philippines (1988–92)[d, e]	96–99.5	
Thailand (1970–90)[d]	96–98	
Ghana (1991–3)[c, d]	85–89	75–83
United Kingdom (1980–90)[f]	95–100	

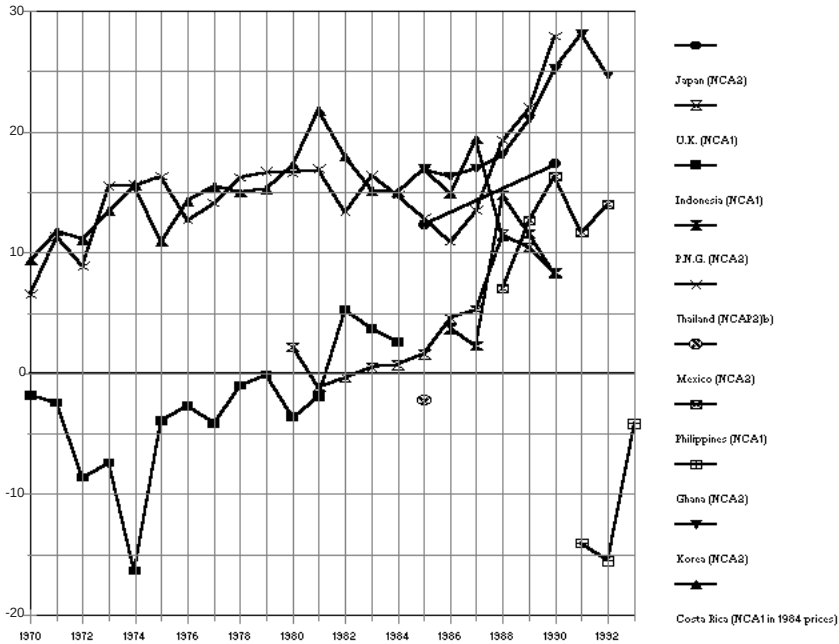
Sources: Costa Rica: Solórzano *et al.* (1991); Mexico: van Tongeren *et al.* (1991); Indonesia: Repetto *et al.* (1989); Japan: Oda *et al.* (1996); Korea: Kim *et al.* (forthcoming); Papua New Guinea: Bartelmus *et al.* (1992); Philippines: Domingo (1996); Thailand: Bartelmus and Tardos (1992); Ghana: Powell (1996); United Kingdom: Pearce *et al.* (1993).
Notes: [a]EDP1 is NDP, adjusted for natural resource depletion only. [b]EDP2 is NDP, adjusted for natural resource depletion *and* environmental quality degradation. [c]Concept adjusted to United Nations (SEEA) methodologies. [d]Preliminary estimates. [e]Soil erosion not yet covered. [f]Oil and gas depletion only.

Table 1 presents these aggregates as obtained from pilot studies of natural resource and environmental accounting. The studies provide information about the significance of natural capital in production and income generation by comparing EDP with NDP. An effort was made to adjust those indicators that were compiled outside the national accounts framework (Indonesia, Costa Rica, United Kingdom) to SEEA concepts. However, as indicated in the table notes, comparability is still impaired by remaining differences in concepts, methods, valuations and coverage of environmental phenomena.

All SEEA applications have taken a cautious approach, leading to undercoverage and underestimation. This may explain some of the rather modest share of depletion and degradation cost in economic performance, especially in the industrialized countries of Japan and Korea.[10] While these countries hardly extract or harvest domestic natural resources, other (developing) countries show more significant effects on their natural capital. Indonesia, Costa Rica and Ghana have been exploiting their natural resources at rates of 10–30 per cent of their NDP (see EDP1 / NDP column of

[10] Current (annual) cost and production measures do not allow for past accumulation of environmental impacts and low current levels of resource stocks, due to past exploitation. Alternative concepts and measures of 'environmental debt' have been proposed to this end (Hueting and Bosch, 1994; National Institute of Economic Research and Statistics Sweden, 1994), but are not directly comparable (like 'cost') to current income and production. Such measures also point to the need for further analysis of the 'responsibilities' of these countries for environmental deterioration in other countries (through natural resource imports and translocation of polluting industries).

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Note: [a] Net capital accumulation (NCA) is defined as net capital formation minus environmental cost; NCA1 refers to net capital accumulation covering natural resource depletion costs only; NCA2 covers depletion and degradation costs.
[b] Elements of NCA1 and NCA2 (low coverage).

Figure 2. *Sustainability of growth (net capital accumulation*[a] *in per cent of NDP).*

Table 1). Probably more important than the overall national aggregates—for structural and sectoral policy and management—are the environmental costs generated by economic sectors. Here the case-studies show that depletion costs generated by forestry and mining reduce conventional value added by over 70 per cent in Mexico and Thailand.

Another way of looking at the (non-)sustainability of economic performance or growth is to assess a nation's ability to generate new capital after taking produced and natural capital consumption into account. Figure 2 presents net capital accumulation (NCA; net capital formation minus natural capital consumption) in per cent of NDP. Indonesia and Ghana (with provisional figures) exhibit non-sustainable growth patterns of disinvestment. Mexico is a possible candidate as far as a one-year result can tell. As already mentioned, the sustainability index for other countries might be overly optimistic due to undercoverage of environmental depletion and degradation, notably in the (preliminary) Thai study.

4. The limits of growth: assessing ecological sustainability

As discussed above, pricing the priceless for economic sustainability has been deemed 'repugnant' by some environmentalists. Others consider it irrelevant. If indeed ultimate limits in the assimilative capacities of the

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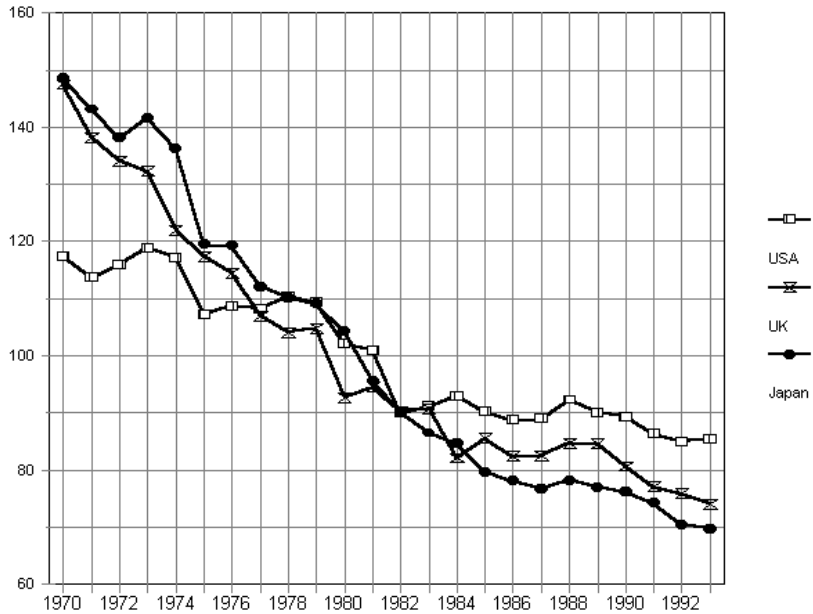
environment and the availability of natural resources are transgressed, continuous functional relationships in conventional economics become meaningless in a system 'riddled with threshold effects' (Perrings, 1995: 63). This situation can only be argued outside standard economic analysis as a case of non-sustainable throughput of energy and materials. Such throughput turns low-entropy mass into high-entropy waste (Georgescu-Roegen, 1971), cutting through the circular economic flow system. Optimal allocation, relative scarcity of resources and perceived economic equilibria lose relevance in Malthusian economics of limited 'scale' of resource flows where absolute scarcities dominate the field (Daly, 1989).

In this situation, sustainability or non-sustainability has to be defined as compliance or non-compliance with capacity limits of natural systems. Attempts have been made to demonstrate the prevalence of these limits in terms of biomass appropriation (Vitousek *et al*., 1986) or by means of carrying capacity assessment (FAO *et al*., 1982; World Bank, 1985), i.e. the ecological sustainability of human populations (see section 2 above). Carrying capacity is usually measured by the number of people a territory can sustain indefinitely, or for a specified time period, at particular standards of living. The problems with carrying-capacity measures lie in assumptions about minimal or desirable standards of living, current and future technologies that may affect the use of available resources, the time horizon of the analysis, and trade with other territories that render the concept inapplicable except at the global level (Cohen, 1995).

Data on material throughput expressed as material intensities of economic activities are more readily available. They have been used to compile proxy indices for pressures on carrying capacities, i.e. of ecological (non-)sustainability. Declining average material and energy intensities in industrialized countries were thus taken as a sign of declining impacts on the environment. Economic growth is considered to be effectively 'delinked' from the environment in this case (Jänicke *et al*., 1989). A later study found, however, that a process of 'relinking' seems to be underway in these countries since the mid-1980s (de Bruyn and Opschoor, 1997).

Figures 3 and 4 show the results of similar calculations for selected materials in the industrialized and developing countries for which case-studies of environmental accounting were carried out (except Ghana and Papua New Guinea, for which data were not available). The only difference is that material input is related to gross domestic product (GDP) rather than population. The reason is that material inputs are more closely related to production (patterns) than to changes in final demand, i.e. final consumption or income per capita. The figures present trends in an 'Index of Material/Energy Intensity' (IMEI) as defined in Figure 3, note (a). The IMEI does indicate a degree of relinking (i.e. an upward movement) of environmental pressures with economic performance for the three industrialized countries of Japan, USA and UK during the 1980s. However, this trend does not seem to continue into the 1990s. For the developing countries, two patterns of IMEI development can be observed. The newly industrializing countries (NICs) of the Republic of Korea, Thailand and Indonesia (and less dramatically Mexico) show trends of increasing IMEI as a possible result of rapid economic growth. By contrast, the Philippines

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Note: [a] Average (for all selected materials) percentage deviation from the average consumption of each material per GDP (1970–93, in constant prices). Materials included are cement, steel, freight (rail and road: net tkm and vehicles in use) and energy. See, for a detailed description of the concepts and method of the index calculation, Jänicke *et al.* (1989) and de Bruyn and Opschoor (1997).
Source: UNSD data bases.

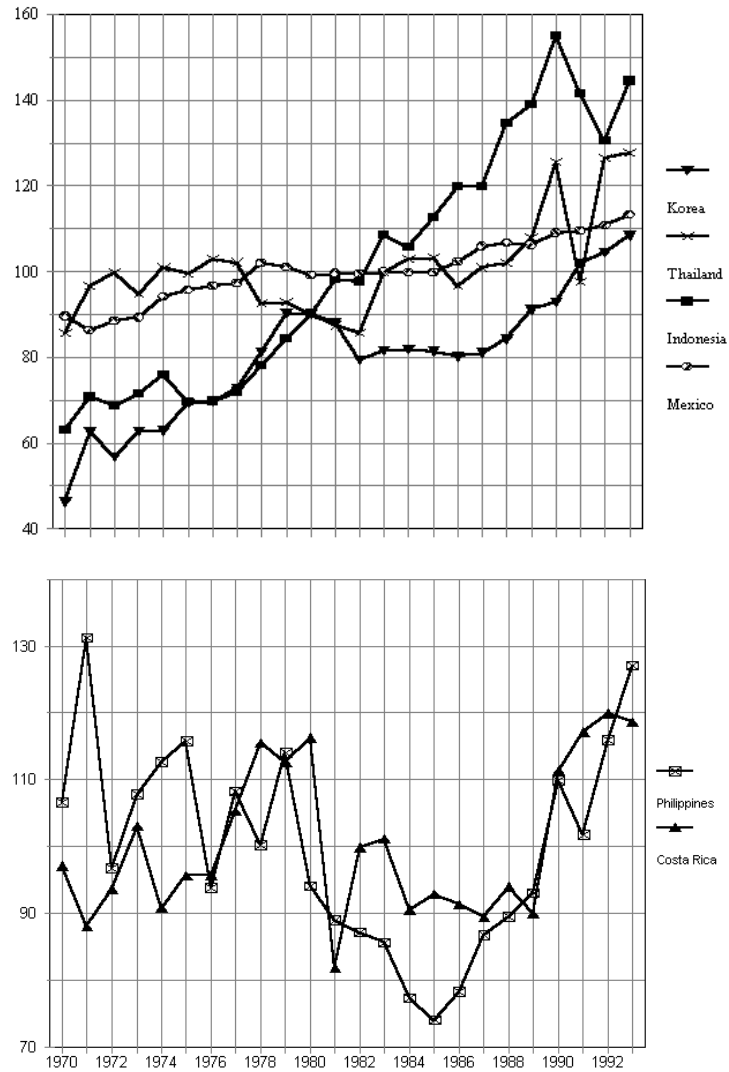
Figure 3. *Index of Materials/Energy Intensity (IMEI)*[a] *in selected industrialized countries (1970–93).*

and Costa Rica exhibit fairly erratic changes in material and energy use in the 1970s and early 1980s. More recently, they seem to follow the material intensity trend (increase) of the NIC economies.

The calculations suffer from the general drawbacks of any physical indicator aggregation, i.e. arbitrary weighting and indicator selection. In the case of IMEI, different environmental impacts produced by different material inputs are given equal weights, possible substitution of materials is not accounted for and the effects of environmental protection are not always reflected in reduced material intensities. Also, and as pointed out by one of the anonymous reviewers, a declining IMEI may be indicative of both an increase in the absolute level of throughput (though relatively lower than the increase in GDP) and an absolute decrease in throughput. De Bruyn and Opschoor (1997) describe these outcomes as 'weak' and 'strong' delinking or 'dematerialization', respectively. All these processes and activities would have to be further examined in more detailed analyses before any policy conclusions could be reached. Such loss of direct usability in policy-making and analysis is another drawback of physical indicators.

The results of monetary environmental accounting and physical IMEI

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Note: [a] see Fig. 3.

Figure 4. *Index of Materials/Energy Intensity (IMEI)*[a] *in selected developing countries (1970–93).*

calculation are hardly comparable. In principle, non-sustainabilities of negative or reduced capital accumulation (because of natural capital consumption) should be reflected in physical material production and consumption patterns. In practice, the empirical results of IMEI compilations do not convey a clear picture of sustainability or non-sustainability of economic growth, and the many assumptions underlying the index calculation make it difficult to derive policy conclusions. So far, it does not

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seem to be possible, therefore, to link unequivocally overall physical indices such as the IMEI to EDP or NCA trends.

What can be concluded from the limited studies available to date is that at least for some, in particular natural-resource-dependent, countries, non-sustainable growth patterns and denial policies, based on conventional economics and indicators, cannot be ruled out. At least those countries would have to take urgent action to reorient their economic and environmental policies towards greater integration and sustainability. This could be achieved along the lines of new paradigms of economic performance, growth and development, discussed below.

5. Towards operational paradigms: eco-nomics and sustainable development

The above results confirm the occurrence of non-sustainabilities of economic performance, brought about by environmental impacts. The question remains whether these impacts, in addition to other, notably monopolistic, market imperfections, are grounds enough to change radically conventional economic planning and policy-making. Ultimate answers to this question can probably not yet be found with the incomplete and imperfect data sets available.

There are, however, at least two immediate benefits of the methodological data work carried out so far, especially in the field of environmental accounting. One is the provision of more operational definitions of sustainability, consistent with standard economic indicators. The other is a clearer demarcation between what can be incorporated into a monetary accounting framework and corresponding empirical analysis, and what has to be assessed by supplementary or alternative indicator systems. Using this demarcation, two basic paradigms of 'eco-nomics' (coined by Postel, 1990) and 'sustainable development' can be distinguished. The former focuses on environmental cost internalization into conventional micro- and macroeconomics; the latter endeavours to comply with social and environmental norms while catering to economic (growth) objectives.

5.1. Eco-nomics: cost internalization and sustainable growth

Eco-nomics can be seen as overcoming the widespread neglect of environmental concerns in conventional market economics. Treating environmental effects of economic activities as 'external' to mainstream market economics might be one reason why environmental policy has frequently been relegated to peripheral agencies or departments. When environment–economy interactions could not be overlooked any more, and calls for integrating environmental and economic policies intensified (WCED, 1987; United Nations, 1993b), the obvious response was to resurrect Pigovian taxes and similar market instruments as a means of cost internalization at the microeconomic level (see, e.g., Dorfman and Dorfman, 1993, ch. 3). The idea is to maintain fundamentals of conventional economics such as competitive markets and optimizing behaviour by establishing individual property rights over public (environmental) goods and/or applying fiscal and other incentives of cost internalization such as effluent charges, tradable pollution permits, or deposit-refund sys-

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tems. Households and enterprises are thus prompted into accounting for environmental costs in their plans, programmes and budgets without impairing the allocative efficiency of the market.

Integrated environmental and economic accounting permits the measurement of the hypothetical (since actual environmental impacts did take place) environmental depletion and degradation cost. These are the costs at which internalization instruments should be set initially and realistically, referring to the best available technologies that could have prevented environmental impacts from current economic activity. The aggregate of EDP and its elements and components thus account for the missed-opportunities cost of not having prevented environmental depletion and degradation. Such costing of environmental sins in consumption and production should facilitate the translation of public declarations in support of sustainability into commitments to environmental protection (expenditure) and 'a specifiable amount of productive investment' (after allowing for natural capital consumption) (Solow, 1992, p. 20).

The ultimate effects of initial cost internalization on economic aggregates would have to be modelled according to prevailing price elasticities and technological (production) structures. As a result, hypothetical aggregates such as an 'optimal net domestic product with regard to environmental targets' (Meyer and Ewerhart, 1996) or a 'maximum NDP generated in an economy in which the burden on the environment is reduced to a sustainable level' (de Boer *et al*., 1994) can be determined. In fact, it can be shown that under certain, quite restrictive and probably unrealistic, conditions of perfect competition, full substitution of production factors and optimal (resource-use) behaviour, such modelling would ensure both maximum output and the long-term sustainability of consumption (Solow, 1974; Hartwick, 1977; Dasgupta and Mäler, 1991). These models can be seen as attempts to accommodate externalities while at the same time reconciling conventional economic analysis with criteria of intergenerational equity (defined as long-term maintenance of per capita consumption).

Overall, economic growth would have to be redirected from GDP maximization towards (more) sustainable growth which can be defined as positive trend in EDP. The assumption underlying this definition is that the allowances made in EDP calculations for the consumption of produced capital and the depletion and degradation of natural capital can and will be invested in capital maintenance, taking into account that trends of depletion and degradation can be offset or mitigated by technological progress, substitution, discoveries of natural resources and changes in production and consumption patterns.[11]

5.2. Sustainable development: from sustainability to feasibility

Costing economic sustainability by incorporating environmental depletion and degradation into national accounts does not capture the 'things that

[11] Other factors such as the effects of natural disasters, changes in the productivity of human capital, or high inflation and indebtedness also affect the sustainability of economic growth. The allowance for produced and natural capital consumption in the above definition reflects therefore only a 'more sustainable' growth concept that requires further refinement (modelling) (Bartelmus 1994a: 70).

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most people think should not be for sale' (Kuttner, 1997: 300). Those 'things' encompass non-economic amenities and values, offered by nature and social institutions, both operating outside the market system. Public institutions may offer political freedoms, security, equity in the distribution of income and wealth, and cultural values. In addition, the disruption of environmental services may cause the loss and impairment of human and non-human lives, as well as inequities in the distribution of these effects within and among nations, and between current and future generations.

Rational and explicit policy analysis would have to specify these needs and values in terms of minimum targets or standards and maximum limits or thresholds, exogenous to the economic exchange system. Those standards and limits may include

- standards of living;
- limits of natural resource capacities;
- pollution and contamination standards;
- limits of the carrying capacity of bioproductive systems;
- distributional standards for income, wealth (including natural assets) and environmental impacts; and
- other cultural, political, social or demographic standards and targets.

Assessing the achievement of these targets and the compliance of human activities with norms and standards is not possible with the above-discussed measures of economic performance or growth. This is because prices or preferences expressed in money terms do not reflect relative scarcities and social priorities and preferences in these areas. For instance, real interest rates might discount much more strongly (over a relatively short period of time) the financial future than social preferences would indicate for the welfare of future generations.

A broader concept of 'development' is needed to overcome the dichotomy between economic and ecological sustainability and to address simultaneously economic objectives and non-economic targets and norms. An operational definition of 'sustainable development'[12] that takes explicit account of economic and non-economic standards and targets has been proposed to this end as 'the set of development programmes that meets the targets of human needs satisfaction without violating long-term natural resource capacities and standards of environmental quality and social equity' (Bartelmus, 1994a: 73).

The consideration of standards, targets or norms turns the question of economic sustainability, defined above operationally as capital maintenance, into one of compliance with social goals or norms. Individual preferences for goods and services, more or less efficiently revealed by markets, may thus be overridden by social fiat, however democratically

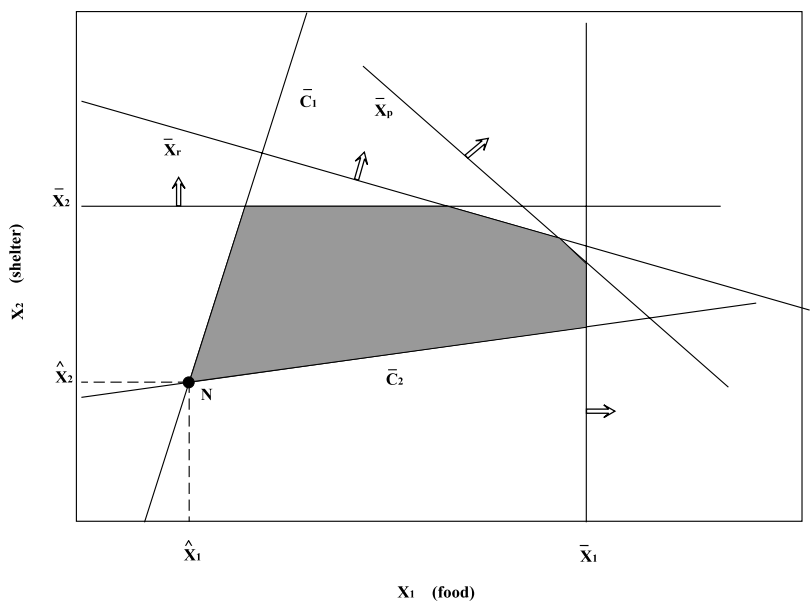
[12] Sustainable development was popularly defined by the Brundtland report *Our Common Future* (WCED, 1987: 43) as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. The definition fails, however, to specify what are the human needs; omits to clarify the timeframe for the analysis of future generations' needs; and does not even mention the environment as the current key concern in sustainability.

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such fiat may have been achieved. Market valuation could be replaced by social *evaluation*, and sustainability by *feasibility* of human activity in terms of non-violation of social norms. To the extent that such standard-setting affects market exchange, a radical change in economic analysis would be required: from a focus on individual preferences to those of 'society', the 'government' or 'expertocracy'. The invisible hand of the market would be overruled by the visible one of the standard-setter(s).

This can be demonstrated by an illustrative model of the size of the 'feasibility space' of interdependent activities (Bartelmus, 1979). This space is generated by limited capacities, standards and norms. Figure 5 shows this for the simple two-commodity economy of food (x_1) and shelter (x_2) production and consumption. Society has to face in this model minimum needs for food ($\bar{c}_1$) and shelter ($\bar{c}_2$), maximum production capacity limits ($\bar{x}_1$ and $\bar{x}_2$) and maximum environmental limits of natural resource availability ($\bar{x}_r$) and pollution ($\bar{x}_p$). The minimum and maximum constraints delimit the shaded area of the economy's feasibility space. Of course, other distributional issues such as the trade-off between intra- and intergenerational equity, i.e. poverty and long-term sustainability of consumption (Solow, 1993), would have to be dealt with in a second-stage 'political space' of decision-making.

Within the feasibility space, conventional micro- and macroeconomic strategies can be played out, aiming at maximum economic efficiency or growth. Outside this space, normative/political criteria overrule economic ones. A wide, open space means that traditional production, consumption and investment activities are hardly affected by social and environmental concerns. In other words, if there is a lot of slack in the feasibility con-



Source: Bartelmus (1979).

Figure 5. *Feasibility space of sustainable development.*

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straints, it will be economics as usual. A largely reduced space, on the other hand, would reveal that markets cannot account for significant interference of non-economic values with conventional economic decision-making. This would indeed end economics as we know it, since socio-political restrictions would surely limit the functioning of markets and market-based economic growth. The neglect or denial of standards and targets of sustainable development might lead in this case to the replacement of development by uncontrolled 'developments' such as poverty-induced riots, war over access to natural resources, eco-terrorism, surge in ecological refugees and other social strife. Since market prices cannot alert to approaching these situations, it would indeed be 'foolhardy to find out the hard way' (Perrings, 1995: 63), i.e. with a *laissez-faire* attitude.

New, environmentally beneficial, technologies could be a saviour, potentially widening the feasibility area. This is indicated in Figure 5 by arrows pushing capacity and environmental constraints 'outward'. The shift of constraints would be reflected in changed technical relations between pollution and natural resource use, and production and consumption. Such a transition from 'limits to growth' to the 'growth of limits' (MacNeill, 1990) might buy some time but cannot be expected to be the cure for all social woes. Moreover, uncertainties in predicting technological progress and environmental impacts present a high risk for relying totally on technology and market expansion and liberalization.

6. Outlook: towards a long-term vision of sustainable development

Instruments of eco-nomics, i.e. of environmental cost internalization by economic agents, have been applied successfully, especially in northern European countries, after 'languishing as arcane concerns of academic environmental economists' (Ekins, 1996: 31). Implementation problems, including the monitoring of environmental impacts, the measurement of marginal damage costs and the short-sightedness of short-lived administrations, seem to have made the use of market instruments more of a tool for revenue-raising than for changing microeconomic behaviour (OECD, 1989). In addition, acute and high-risk environmental phenomena such as the depletion of atmospheric ozone would have to be tackled by immediate regulative action rather than through time-lagged 'marginal' prompting by economic (dis)incentives. The use of these instruments is thus still in an experimental phase. Experimentation, notably with a more realistic setting of these instruments—at a level determined by measurements of environmental cost in consistency with national accounts concepts and indicators—is perhaps the most promising way to achieve economic sustainability in the short and medium term.

Non-economic objectives, such as intergenerational fairness, and potentially irreversible threshold effects on life-support systems call for guarding against violation of social goals and environmental limits in current and future economic activity. This may indeed require sacrificing short- and medium-term efficiency for the sake of incorporating 'vital' standards into long-term economic planning and policy-making. Positive and normative economics would thus be merged by explicitly introducing standards and norms into economic analysis—anathema to many economic scientists (see, e.g.,

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Caldwell, 1982: 4 and part II; or Samuelson and Nordhaus, 1992: 9, 295). However, such merging is unavoidable in real-world politics. Much of the irrelevance of economics might thus be the consequence of the prevailing positivist approach of 'puzzle-solving in ignorance of the wider methodological, social and ethical issues' (Funtowicz and Ravetz, 1991: 138).

Sustainable development was shown above to be the widely advocated paradigm capable of incorporating these wider issues in an integrative vision of environment and economy. Implementation of such a paradigm cannot be achieved through short-term market clearance. A first step towards implementation is to make vision visible: the above-described illustrative model of a feasibility space might serve this purpose by setting economic activities into a framework of explicitly stated goals and standards. The next step of quantifying the model would be more difficult. For instance, in order to apply the tools of activity analysis, norms and standards have to be formulated in units of means (inputs) and ends (outputs) of activities which in turn would have to be fully reflected by some functional, quantifiable and realistic, relationship between inputs and outputs. Such analysis might be usefully tackled by collaborative research of positivist and normative economists.

Beyond analysis, social 'compacts' need to be established between decision-makers and stakeholders to achieve the setting of and compliance with norms and standards in economic planning and decision-making. At the national level, such compacts could be negotiated between government and civil society on a voluntary basis, or would have to be enforced by law and regulation. The chances for effective implementation of social compacts and long-term planning for sustainable development seem to be slim, in the wake of market euphoria brought about by the downfall of central planning. Also, entrenched 'asymmetries in power and knowledge' (Kuttner, 1997: 285) and uncertainties about the extent, location and timing of environmental impacts are not conducive to the adoption of an overarching visionary approach like sustainable development by 'introvertive' (Heilbroner and Milberg, 1995: 101) economists.[13]

The answer to 'whither economics?' may well have to come from the next generation of potential eco-nomists. To cite a recent communication to the author from a Canadian eighth-grade study group, enquiring about how to maintain the Earth's productivity for future generations:

> It is our responsibility as the Earth's next peoples to be held accountable for what is, and what will happen to our Earth if we do not take care of it.[14]

[13] Achieving consensus through direct negotiation might be easier at the local or community level—an argument for implementing participatory grass-roots strategies of 'ecodevelopment'; see, for a review of these bottom-up approaches and their links to central planning and policies, Bartelmus (1994a). Much of the generic discussion of sustainable development applies also at the local level and is therefore not pursued here.

[14] Beth Hall, Gladstone Elementary School, Gladstone, MB (for the Sustainable Development Group).

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