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Chapter 1

FIVE WAYS TO COMBAT MISLEADING INFORMATION ABOUT ECONOMIC GROWTH

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ABSTRACT

Welfare, to which all economic action is directed, is defined as the satisfaction of wants derived from our dealings with scarce goods. It is a category of personal experience and not measurable in cardinal units. Therefore we have to make do with indicators that *are* measurable in cardinal units and that are arguably influencing welfare. The cardinal indicator and the ordinal welfare have, of course, to develop in the same direction.

Economic growth is generally defined as increase of national income (NI) (or GDP) as a measure of production. However, according to the subject matter of economics economic growth can mean nothing other than increase in welfare. Welfare is dependent on more factors than solely production. It is also dependent on employment, income distribution, labour conditions, leisure time and the scarce possible uses of the non-human-made physical surroundings: the environmental functions. These objectives or ends are often conflicting. Therefore welfare can increase with decreasing production.

The narrow minded, theoretically wrong definition of economic growth is especially threatening the current and future availability of environmental functions, the most fundamental scarce and consequently economic goods at the disposal of humanity. These fall outside the market and outside the measurement of NI. Correct information is decisive for the coming into being of the preferences of individuals and institutions and consequently for the decision making process. Therefore it is of the utmost importance to correct the current misleading information. In this contribution five relatively simple ways are discussed to correct the wrong information about economic growth.

Environmental sustainability is defined. National income ex asymmetric entries and environmentally sustainable national income (eSNI) are discussed. It is shown why it is implausible that sustainability can be attained with growing production.

1. Economic Growth According to the Subject Matter of Economics

The view now accepted by the mainstream of economic thought is that the phenomena arising from scarcity together form a logical entity, irrespective of the end for which the scarce means are employed. This is referred to as the formal or indifferent concept of welfare, a term probably introduced by Rosenstein-Rodan (1927). What he wrote can be summarized as follows. The subjective state of welfare or the total economic utility that people endeavour to achieve in their economic activities is a quantity determined purely formally. It encompasses all that has been striven after, to the extent that scarce goods have had to be used for achievement thereof, irrespective of (indifferent to) whether such pursuit springs from egoistic or altruistic, from ethical or unethical motives, from ‘real’ or ‘imaginary’ wants.

It was Robbins ([1932] 1952) and Hennipman (1940, 1943, 1962, 1995), among others, who elaborated the formal concept of welfare and formulated its consequences for economic theory. For these authors, the subject matter of economics is demarcated by the criterion of scarcity. The subject matter of economics is defined as the problem of choice with regard to the use of scarce, alternatively applicable means for the satisfaction of classifiable wants. According to Hennipman it is therefore logical and consistent to interpret welfare, the end and result of economic activity, as the overall satisfaction of wants pursued or obtained by means of economic goods or, more precisely as the balance of the positive utility over the negative utility caused by external effects or productive efforts. In Hennipman’s view economic activity can serve all kinds of ends. The ends themselves are meta-economic and are not for economists to judge. They cannot be derived from economic theory, nor are they amenable to it, they must be taken as given, as data. In the same vein, Robbins writes: ‘There are no economic ends as such; there are only economic problems involved in the achievement of ends’.

Maximizing or even just increasing the social product (NI) should therefore, in Hennipman’s view, no longer be considered a necessary end that can lay claim to logical priority. All those objectives aspired to by economic subjects that conflict with that end belong logically and in their entirety to the domain of economic policy. If preference is given to those objectives, he writes, this does not mean a sacrifice of welfare on the strength of ‘non economic’ considerations, as it is still frequently represented, since economic goods are then being utilized in accordance with the wants of the subjects and thus to the benefit of their welfare.

Proceeding from the work of these authors, Hueting (l974/1980) posits the following. All economic activity is aimed at the satisfaction of wants, and consequently *the term economic growth can mean nothing other than increase in welfare* defined as the satisfaction of wants derived from our dealings with scarce goods. Welfare is not a quantity that can be measured directly ‘from outside’; it is a category of individual experience. It is for this reason that the statistician focuses in practice on charting trends in factors that *can* be measured and that can plausibly be argued to have an influence on welfare. These factors will not generally be strictly proportional to welfare but must at any rate satisfy the condition that they tend consistently in the same direction as the welfare they are indicating, positive or negative. The following welfare-influencing factors can be distinguished:

1. the package of goods and services produced;
2. scarce environmental functions;
3. time, that is leisure time;
4. the distribution of scarce goods, that is income distribution;
5. the conditions under which scarce goods are acquired, that is labour conditions;
6. employment, or involuntary unemployment; and
7. future security, to the extent that this depends on our dealings with scarce goods, and specifically the vital functions of the environment.

These factors are often in conflict with one another, although this is not always the case. For scarce goods it holds by definition, however, that more of one is less of another, for a good is scarce when something else has to be sacrificed in order to obtain it (sacrificed alternative, opportunity cost). The days when environmental functions were free goods are gone. All other things remaining equal (including technological state of the art), more production therefore means less environment and vice versa. When, in the margin, for whatever motive, preference is given to the environment over production and a government proceeds to impose controls on production processes and consumption habits that lead to a smaller volume of goods and services produced, there will be an increase in the overall satisfaction of wants obtained by means of scarce goods. *A decrease in production will then lead to greater welfare.* It is therefore misleading to identify growth of national income with an increase in welfare, economic growth and economic success, as is still common practice even today. This terminology is fundamentally erroneous in its implications, to the detriment of the environment, and it should therefore be outlawed, in much the same way as discriminatory language against women.

2. THE CONCEPT OF ENVIRONMENTAL SUSTAINABILITY

The concept of environmental sustainability denotes a state of *dynamic* equilibrium between production and natural resources. J.S. Mill (1876) wrote that he sincerely hoped that people would be content to be stationary, for the sake of posterity, long before necessity compels them to it. This pronouncement can be interpreted as being based on considerations of intergenerational equity. In the context of sustainable national income (see Section 7) this means that it is investigated under which conditions the *possibilities* to use our non-human-made physical surroundings can be passed on to future generations undamaged. In the twentieth century the notion of sustainability has been extended to encompass other aspects of the environmental issue, such as the relation with the living world (nature) and pollution; see IUCN (1980)].

In the process, the principle of preferences for intergenerational equity has always remained a core element of the concept. This implied a state of dynamic equilibrium with the available natural resources and with the living world, and abatement of pollution, to the extent of its significance for future generations. Uncompensated exportation of anthropogenic environmental risks to future generations was rejected as inadmissible. To establish an appropriate maximum environmental burden to meet these preferences was seen as a task for natural scientists. In other words, sustainability was taken to mean that the environmental capital - defined as the possible uses, or functions, of the environment and natural resources - provided by nature and capable of being scientifically established, should remain intact; see Kapp (1950), Daly (1973), Hueting (1974/1980), and Goodland (1995).

This implies a dynamic equilibrium, in which (ceteris paribus) the functions of the non-human-made physical surroundings remain available. Measures taken to allow for the permanent availability of functions should be derived from scientifically based presuppositions. Whether these measures are sufficient can of course only be evaluated after the event, again using natural science. So in this view environmental sustainability is an objective concept to the extent that natural science is objective. Whether or not individuals and institutions want to attain environmental sustainability depends on their preferences which are evidently subjective.[1] The equilibrium is dynamic because both geological processes and human activities are continuously changing the state of our planet.

In the report Our Common Future (1987), also known as the Brundtland report, the concept of sustainability was clearly linked to the issue of intergenerational equity. In Our Common Future this was phrased as follows: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Many countries have by now subscribed to sustainable development as defined in the Brundtland report. However, the report is according to Hueting (1990) a matter of conflicting goals, because it is pleading for both sustainability and production growth; see Section 8.

3. The Concept of Competing Environmental Functions

In the theoretical basis for the calculation of environmentally sustainable national income (eSNI, see Section 7), the environment is defined as the non-human-made physical surrounding, or elements thereof, on which humanity is entirely dependent in all its doings, whether they be producing, consuming, breathing or recreating. These physical surroundings encompass water, air, soil, natural resources, including energy resources, plant and animal species and the life support systems (including ecosystems) of our planet. It is true that our observable surroundings are largely human-built. However, houses, roads, machines and farm crops are the result of two complementary factors: labour, that is technology, and elements of the physical surroundings as here intended. Our crops, for example, have been bred or manipulated from genetic material taken from natural ecosystems; this material was not created by human beings and sooner or later we shall most probably have to fall back on it. We therefore continue to be dependent on the functions of the physical surroundings as here intended, including the functions of ‘gene pool’ (or: ‘gene reserve’), ‘habitat for biological species’, ‘water as raw material for drinking water’, ‘air for the physiological functioning of human beings, animals and plants’, ‘soil for cultivating crops’ and the many functions of non-renewable natural resources.

Producing is defined, in accordance with standard economic theory, as the adding of value. This value is added to the physical elements of our environment. In this process one good is transformed into another in order to satisfy wants. The values are added by labour, that is hands and brains, with the brains guiding the hands, so that we are concerned

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[1] Because they reflect the feelings of subjects

ultimately with two factors: labour (technology) and environment. Thus, both consumption goods and capital goods embody a combination of the physical elements of the environment, on the one hand, and labour, accumulated or otherwise, on the other. In this view, labour and environment are the two factors with which humanity has to make do in securing a desired level of consumption. If environmental functions are lost we are left literally empty-handed. Environment and labour are thus complementary. Annual production as measured in the standard national income is therefore accompanied by a *physical flow of goods*. Put differently, regardless of whether the products are actually physical, in production and consumption there will always be an interaction with the physical environment and consequently always a physical burden on that environment. This environmental pressure is, obviously, a form of environmental use.

In our physical surroundings (the environment) a great number of possible uses can be distinguished, which are essential for production, consumption, breathing, et cetera, and thus for human existence. These are called environmental functions, or in short: functions (see Hueting 1969, 1974/1980). These functions have come into being largely via processes proceeding at a geological or evolutionary pace. For the life support systems it is unfeasible ever completely to be replaced by technology, as is shown by Goodland (1995). It is thanks to these life support systems, which are under threat of disruption, that indispensable (or vital) environmental functions remain available.

Life support systems are understood to mean the processes that maintain the conditions necessary for life on earth. This comes down to maintaining equilibria within narrow margins. The processes may be of a biological or physico-chemical nature, or a combination thereof. Examples of biological processes include the carbon and nutrient cycles, involving the extraction of such substances as carbon dioxide, water and minerals from the abiotic environment during creation of biomass, and the return of these substances to the abiotic environment during decomposition of the biomass. Examples of physico-chemical processes include the water cycle and regulation of the thickness of the stratospheric ozone layer. These examples show that there is interaction between the processes, whereby equilibrium may be disturbed. The water cycle, for example, may be disturbed by large-scale deforestation. Climate change is a disturbance of the carbon cycle.

As long as the use of a function does not hamper the use of an other or the same function, so as long as environmental functions are not scarce, an insufficiency of labour, that is intellect or technology, is the sole factor limiting production growth, as measured in standard NI. As soon as one use of a function is at the expense of another or the same function (by excessive use), though, or threatens to be so in the future, a second limiting factor is introduced. As an illustration, once certain water pollutant thresholds have been exceeded, use of the function ‘dumping ground for waste’ may come to compete with the function ‘drinking water’. An example of excessive use of one and the same function ‘water to accommodate the habitat for (one or more) fish species or ecosystems’, leading to its loss, is overfishing resulting in decreased availability of the function; then the catch of some species decreases or species become extinct; many species and ecosystems of which they were a part, in other words many functions, have indeed already been lost. The function ‘soil for cultivating crops’ may be damaged by unsustainable use of the function ‘supplier of timber’ of a forest, leading to loss of its function ‘regulator of the water flow’ and subsequent erosion; it may also be in conflict with itself, when unsustainable farming methods lead to erosion and salinization of the soil. The many functions of natural resources that threaten to get lost as a result of exhaustion of the resource are in competition with themselves; see Appendix. This competition of functions leads to partial or complete loss of function.

Competing functions are *by definition* economic goods. If, at a given level of technology, use of function A is at the expense of use of function B, greater availability of function B will lead, one way or another, to reduced availability of function A; conversely, more of A will lead to less of B. An alternative will always have to be sacrificed (opportunity costs) and consequently both A and B are scarce - and consequently economic - goods. Here, 'use' obviously also includes passive use such as designation of an area as a nature reserve, which thereby excludes other uses, following recognition of the right of other species to exist; the sacrificed use, or sacrificed alternative, constitutes the opportunity cost. Competing environmental functions, defined as economic goods, form the theoretical backbone of the environmentally sustainable national income (eSNI) and its estimation. See Section 7.

In this way the environment, and environmental losses, acquires a central place in economic theory, in contrast to an approach whereby these losses are viewed as external effects. The subject matter of economic theory can then be formulated as follows: the problem of choice with regard to the use of the scarce, alternatively applicable, dead and living matter of our physical surroundings for the satisfaction of classifiable wants. Or, very briefly: arranging the dead and living matter of the environment according to our preferences. This is argued in Hueting (1974/1980) and, more extensively, in Hueting (1992, 1995). One of the arguments can be stated succinctly as follows. In the literature external effects are defined, briefly, as unintended side-effects outside the market affecting third persons, non-market parties; for a more extensive definition, see Hennipman (1968). However, when a road is built through a nature reserve, or a sewer to a river, estuary or sea, and all citizens make equal use of the road or sewer, the same citizens nonetheless lose important functions, in part or *in toto,* and such decisions are often made intentionally, in full awareness of the consequences.

The availability of environmental functions is the degree to which those functions can be used for a given end. This depends on two factors: one objective and measurable, the other subjective and not directly measurable. *On the one hand,* the availability of functions depends on the quality, quantity and spatial extent of environmental elements such as water and soil, which are largely amenable to measurement in physical units, and on the likewise measurable functioning of systems, including, specifically, ecosystems and life support systems, or in other words on the state of the environment. Through (over-) use of a certain function the state of the environment may be altered, leading to reduced availability of other functions or of the same function: competition between functions. Whether this happens, and to what extent, depends on the preferences of the economic subjects. The availability of functions is thus also dependent, *on the other hand,* on subjective preferences, which are not directly measurable. In Hueting (1974/1980) this is expressed in a system of coordinates with on the horizontal axis the availability of functions expressed in terms of a physical variables (units, parameters) and on the vertical axis the preferences and costs associated with restoration and maintenance of functions (see Section 4). *In this way the relationship is established between subjectivist economic theory and the measurable physical environment, or ecology.*

Three categories of competition between functions are distinguished: spatial, quantitative and qualitative.

Spatial competition occurs when the amount of space is inadequate to satisfy existing wants, or threatens to be so in the future. Worldwide severe competition exists between use of space for production of food, production of bio fuels, natural ecosystems and the survival of species, road building, building of houses, traffic and possibilities for children to play and discover their surroundings. Especially the function ‘space for the existence of natural ecosystems’ is threatened. Spatial competition is probably the main cause of species extinction, through loss and fragmentation of habitats. Everything points to this process continuing in accelerated tempo unless drastic measures are taken. Conservation of natural species is a key criterion for estimating the Sustainable National Income according to Hueting (see Section 7).

In the case of quantitative competition, it is the amount of matter that is deficient or threatens to be so in the future. We are here concerned with natural resources such as oil, copper and groundwater, which are exhaustible and non-renewable on a human time scale or which cannot increase in quantity, such as water. In many regions of the world the quantity of ground and surface water is insufficient to meet the needs for both raining on agricultural crops and industrial processes and drinking water and the survival of species.

With qualitative competition, it is always one and the same function, the function ‘waste dumping medium’, or much more accurately: ‘addition or withdrawal of species and matter’ that is in conflict with other possible uses such as ‘drinking water’, ‘physiological functioning of humans, plants and animals (breathing)’ and ‘habitat for species’. The introduction of agents into the environment (water, soil and air) or their withdrawal from it, in the course of a given activity, alters the quality of these environmental media, and as a result other uses of them may be disturbed or rendered impossible. Here, an ‘agent’ is defined as an abiotic or biotic element or amount of energy (in whatever form) introduced into or withdrawn from the environment that can cause loss of function. Thus, agents may be chemical substances, plants, animals, heat, ionizing radiation and so on. Qualitative competition includes pollution, disturbance of ecosystem by exotics and phenomena such as climate change.

When using the concept of function, the only thing that matters in the context of environmental sustainability is that vital functions remain available. As for renewable resources, functions remain available as long as their regenerative capacity remains intact. Regeneration in relation to current use of 'non-renewable' resources such as crude oil and copper that are formed by slow geological processes is close to zero. Regeneration then takes the form of developing substitutes. The possibilities for this are hopeful; see Brown et al. (1998) and Reijnders (1996). So, economically speaking, there seems to be no essential difference between the two.

Competition between functions is a manifestation of the finite nature of the environment, and to trace this competition in appropriate matrices is to expose the underlying conflicts. This has been done by Hueting (l974/1980). The conflict proves to lie almost entirely in the use of environmental functions for production and consumption, and growth thereof, in the here and now, at the expense of other desired uses and of future availability of environmental functions, including those functions necessary for production and consumption. In other words, the conflict boils down essentially to a question of sustainable versus unsustainable use of environmental functions. An elaboration for the use of the functions of a rainforest has been published by Hueting (1991).

For a proper understanding of the economic aspects of the environment it is instructive to compare the concepts outlined above with the concepts traditionally used in economic theory. This is no more than a metaphorical exercise, however, as the two categories of concepts are ultimately incompatible. Thus, some functions of the physical surroundings can be seen as consumption goods. Examples include: ‘air for physiological functioning (breathing)’, ‘water as raw material for drinking water’ and ‘swimming water’. Other functions can be viewed as production means, such as ‘water for irrigating crops’ and ‘gene pool for breeding and modifying crops and livestock’. However, ‘normal’ consumption goods and production means have to be reproduced over and over again, while environmental functions remain, in principle, freely available. Only if they come to compete, with each other or with themselves, for example if certain thresholds are exceeded, does their continued availability require a sacrifice. Finally, what was termed ‘the non-manmade physical surroundings’ in Hueting (1974/1980) is now often referred to as ‘natural capital’. This, too, is instructive, but once again there is an anomaly: ‘normal’ capital goods wear out, but natural (or environmental) capital does not, in principle.

These differences in terminology make no difference when it comes to the valuation method elaborated in Section 4. After all, capital goods derive their value from the value of the consumption goods they are used to produce, and thus ultimately from preferences for these goods. Similarly, environmental capital, or the physical surroundings, derives its value from the value of its possible uses, the environmental functions, and thus from preferences for these functions. The elimination measures are of course always aimed at conserving water, air, soil, ecosystems, and so on, and thus at natural capital as the vehicle of the functions.

4. Valuation of Environmental Functions: A Practical Solution for an Unsolvable Problem

The emergence of competition between functions marks a juncture at which functions start to fall short of meeting existing wants. Competing functions are by definition scarce and consequently economic goods, indeed the most fundamental economic goods humanity disposes of. In a situation of severe competition between functions, in which we live today, labour is not only reducing scarcity, and thus causing a positive effect on our satisfaction of wants, or welfare; but it is also increasing scarcity, thus causing a negative effect on welfare. The same holds for consumption. So today production not only adds value (viz. goods for consumption) but also nullifies value (by damaging environmental functions).

The availability of functions, or, in terms of the System of National Accounts (SNA), their volume, decreases from ‘infinite’ (abundant with respect to existing wants) to finite, that is falling short with respect to existing wants. As a result, the shadow price of environmental functions rises, and with it their value, defined as price times quantity, from zero to an ever-higher positive value. *This rise in value reflects a rise in costs*. To determine the extent of the loss of function, we must know the value of the function. Since environmental functions are collective goods that are not traded on the market, supply and demand curves have to be constructed. Without data on *both* preferences (demand) *and* opportunity costs (supply), determination of value is impossible. For, if a good is not wanted or if it’s acquisition requires no sacrifice, the economic value of that good equals zero and no problem of choice arises. It then is obviously not scarce, has by definition no economic aspect and falls consequently outside economics.

The estimated costs of measures necessary to restore functions, that rise progressively per unit of function restored, can be seen as a supply curve, because it supplies the function. We call this the cost-effectiveness curve or the elimination cost curve, because it refers to measures that eliminate the pressure on the environment. Except in the case of irreparable damage, the elimination costs can always be estimated, so this curve can always be constructed. The measures include technical measures, direct shifts to environmentally benign production and consumption, development of alternatives for depletable resources such as oil and cupper, and family planning. See Appendix for the necessary pace of substitution of non-renewables.

Preferences for environmental functions (demand), on the contrary, can only partially be determined, since the possibilities for preferences for the current and future use of environmental functions to manifest themselves in market behavior are very limited (Hueting, 1974/1980). Therefore efforts have been made to trace these preferences by asking people how much they would be prepared to pay to wholly or partially restore lost environmental functions and to conserve them. Much research is being done on willingness to pay or to accept (contingent valuation). However, this method does not always provide reliable estimates for many reasons.

1. Information on the significance of environmental functions is deficient in many cases. This is especially so for the functions that determine the future quality of the environment. With respect to the functions of the life support systems there is often a question of the risk that interrupting complicated processes, for instance ecosystems and climate, may lead to serious overshoots and collapse, versus the chance that technologies not yet invented may cope with those risks. Many people may not be able to weigh these risks and chances, and thus to answer how much they are prepared to pay for avoiding them. According to the biological literature the possibility that overshoots and collapse may occur if the growth pattern of production (and population) is not changed constitutes the most important part of the environmental problem (see, for example, Odum 1971). If individuals are not aware of the importance of an environmental function, the survey method is pointless.
2. There is a considerable difference between saying that one is willing to spend money on something and actually paying for it.
3. The questioning method in fact tries to approach the value of a collective good as if it were a private marketable good (by trying to find some points on the demand curve). In a market the bidder knows fairly well what quality and quantity can be acquired by different bids. In a collective situation, however, this is not possible, because it is not known how much other people are going to bid. Without a considerable amount of additional research it is also not known how much money is required to attain different quality standards for the environmental functions.
4. In order not to make the questioning unjustifiably vague, some research on environmental accounting has to be done beforehand. For clear air, clean water, and so forth are not homogeneous goods from an economic point of view, as water and air have quite a few different economic functions. If the persons being questioned are to have a clear picture of the issues, they must be given information on the significance of the different functions, the consequences of their loss, and the measures and costs involved in their restoration. All together this constitutes a huge

amount of information, which would not be easy to survey. Although the willingness-to-pay method might be justified for one or two factors affecting the immediate living conditions of people asked, it is not a sound base for correcting national income.

5. Much of the damage resulting from the loss of functions will take place in the future. No financial damage or compensation expenditures, as revealed preferences, can therefore arise in the present. Choosing a discount rate boils down to making an assumption about preferences and therefore does not resolve the problem; see Hueting (1991). Another example is that we cannot base ourselves on observed individual behaviour, given the working of the prisoners' dilemma.
6. People may be interested in the effects of their bids, together with the (unknown) bids of others, on, for instance employment levels and consumption patterns. For answering legitimate questions about this, scenario studies have to be elaborated, and the results have to be presented to the persons questioned. This hardly seems feasible. Again, what might be justified on a micro scale is most probably not justified on a macro scale.
7. Asking people how much they are prepared to pay, suggests that conserving the environment always requires extra provisions that must be paid for. In quite a few cases, however, conservation is a matter of refraining from doing things rather than of doing them, and this saves rather than costs money. Thus not building a road through a mountainous area that is vulnerable to erosion is cheaper than building it, cycling is cheaper than driving, wearing a sweater and using an extra blanket is cheaper than raising the temperature, and confining the consumption of lettuce to the summer season is cheaper than eating it throughout the year. People who realize this may modify their answers because of such considerations.
8. Some people will probably be convinced that it does not matter what they bid, because their bid will not influence environmental policy at all, and this conviction will influence their bid.
9. Some people may think they have a "right" to a healthy and safe environment and will probably react accordingly by not making a bid at all.
10. People will probably have their doubts about the participation of others (the Prisoner's Dilemma from game theory) or prefer to wait and see (the Free Rider Principle from the theory of collective goods). Thus in developing countries, where the tropical rain forests are, the view is widespread, for a number of reasons, that people from the rich countries should pay for their conservation.
11. In cases where the whole community is involved, the willingness-to–accept approach is pointless. For who is paying whom to accept the loss?
12. The environment is an important collective good. But it is not the only one. Dikes, public administration and the army are too, while police and education have clear collective properties. To be sure of not exceeding budget restrictions, people also have to be questioned about how much they are prepared to pay for the other collective goods of the society. This hardly seems feasible. Again, what might be justified for one or two separate environmental agents on a micro scale may be impossible on a macro scale.
13. The willingness-to-pay method also measures the consumer's surplus. In national income the total value of the goods is found by multiplying the quantity of each good

by its respective price and then adding together the resulting amounts. Using this procedure, the consumer's surplus is not expressed in the level of national income. Thus, a doctor who saves a patient's life creates a value that, whatever one may think about its exact size, is certainly higher than the value added recorded in national income. The intra-marginal utility of goods, which is ignored in national income, will approach an infinite value, because it includes the utility of the first unit of food, drink, and so forth. For this reason the results of willingness-to-pay research are not suitable to be used in conjunction with the figures of national income. An additional objection to incorporating the consumer's surplus in the willingness-to-pay approach is that the results reflect the income distribution more directly than do the prices of market commodities; the differences between rich and poor in the weights of the "votes" become greater when the consumer's surplus is included. The occurrence of differences in weights of "votes" is often defended by the argument that the contribution to the national package of goods and services by the rich is greater than by the poor: their incomes are higher because of the greater relative scarcity of their abilities. This argument is not valid with regard to the environment, because it is not produced by humanity.

Because of the limitations mentioned above, the willingness-to-pay method does not present a firm enough basis for correcting national income for losses of scarce environmental functions. A correction based on this method may lead to inaccurate estimates of environmental decline.

Consequently, it is not possible to construct a complete demand curve. Expenditure on compensation for loss of function and on restoration of physical damage resulting from loss of function, however, constitute revealed preferences for the availability of functions, so that some impression of these preferences can be obtained. One example is the additional measures for the production of drinking water as a result of the loss of the function 'drinking water' because of pollution (overuse of the function 'water as dumping ground for waste'). Another example is the restoration of damage caused by flooding due to excessively cutting forests etc. (overuse of the function 'provider of wood' etc.) that consequently are losing their function 'regulation of the water flow'.

Because individual preferences can be measured only partially, shadow prices for environmental functions, which are determined by the intersection of the first derivatives of the constructed curves for demand and supply (see Figure 1), cannot be determined. Consequently, these shadow prices – and the value of environmental functions - remain unknown. This means that the *correct prices for the human-made goods* that are produced and consumed at the expense of environmental functions, and on which the NI is based, remain *equally unknowable*. However, to provide the necessary information, assumptions can be made about the relative preferences for environmental functions and produced goods.

One of the possible assumptions is that the economic agents, individuals and institutions, have a dominant preference for an environmentally sustainable development. This assumption is legitimate since governments and institutions all over the world have stated support for environmental sustainability. Furthermore Hueting (1987), referring to the ecological risks by production growth, postulates: "Man derives part of the meaning of existence from the company of others. These others include in any case his children and grandchildren. The prospect of a safer future is therefore a normal human need, and dimming of this prospect has a negative effect on welfare." The environmentally sustainable income (eSNI), described in Section 7, is based on the assumption of preferences for environmental sustainability. *Another* possible assumption is that the economy is currently on an optimal path that is described by the changes in the standard NI.

So *both the eSNI and the standard NI are fictitious* in the context of what is at issue in economic theory and statistics, namely to provide indicators of the effect of our actions on our welfare. This holds true apart from the fact that measuring NI has smaller uncertainty margins than measuring eSNI.

When assuming dominant preferences for sustainability, the unknown demand curves must be replaced by physical standards for sustainable use of the physical environment. The standards are scientifically determined and in this sense objective. They must, of course, be distinguished clearly from the subjective preferences for whether or not they should be attained. Examples are: the man-made rate of extinction of species should not exceed the rate at which new species come into being, for safeguarding the many functions of ecosystems; the emission of greenhouse gases has to be reduced by 70 to 80 % in order to let life support systems restore the climate; the rate of erosion of topsoil may not exceed the rate of formation of such soil due to weathering, for safeguarding the function: 'soil for raising crops'. See also Appendix.

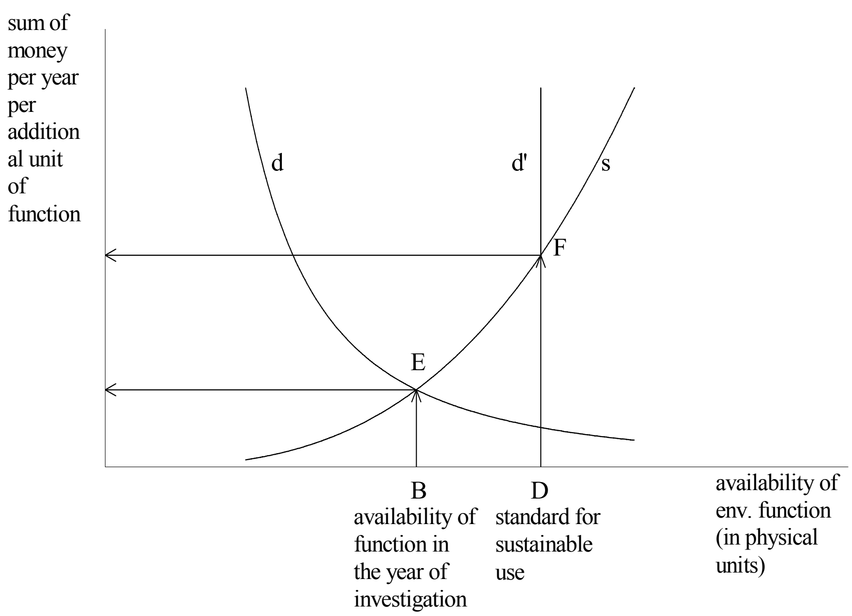

Figure 1. Taken from Hueting (1974/1980). Translation of costs in physical units into costs in monetary units: s=supply curve or marginal elimination cost curve; d=incomplete demand curve or marginal benefit curve based on individual preferences revealed from expenditures on compensation of functions, and so on; d' = 'demand curve' based on assumed preferences for sustainability; BD = distance that must be bridged in order to arrive at sustainable use of environmental functions; area BEFD=total costs of the loss functions, expressed in money; the arrows indicate the way in which the loss of environmental functions recorded in physical units is translated into monetary units. The availability of the function (B) does not need to coincide with the level following from intersection point (E).

From an economic perspective, sustainability standards approximate demand curves that are vertical in the relevant area of a diagram that has the availability of functions measured in physical units on the *x*-axis and the demand for functions and their opportunity costs on the *y*-axis. The shadow price for environmental functions – and their value – based upon the assumed preferences for sustainability then follows from the intersection of the vertical line and the marginal cost-effectiveness curve. In this manner the distance to sustainability, denoted in physical units on the *x*-axis, is translated into monetary units. See Figure 1, taken from Hueting (1974/1980), which shows the *relationship between economy and ecology*. Of course, bridging the gap requires a transition period.

The greater the distance between the present economy and the desired more environmentally benign economy that has to be bridged, the higher the costs of the required set of elimination measures are, as Figure 1 shows. These measures, consisting of technical means to reduce the use of the environment, direct shifts to less environment-damaging products and, if necessary, birth control, are interacting with deliveries of all products, including services. So, when bringing these measures into practice, the interdependences between the producers, consumers and the environment make all commodity flows and prices change. For a correct approximation, such calculations have to be done by a general equilibrium model, which also generates the shadow prices for produced goods in a sustainable economy. The level of sustainable national income (see Section 7) follows from such a model as well.

5. Five Ways to Combat Misleading Information about Economic Growth

Based on the information described above, five ways can be distinguished to improve the current information about economic growth.

6. First Way: Publish a Series NI's Ex Asymmetric Entries (asyms) alongside the Standard NI's

Producing is defined, in accordance with standard economic theory, as the adding of value. National income (NI) equals the sum of the values added. So NI measures - the fluctuations in the level of - production. It does so according to its definition and according to the intention of the founders of its concept to get an indicator for one of the factors influencing welfare - and a tool for quite a few other purposes. See Tinbergen and Hueting (1991/1992). (Nobelist Jan Tinbergen was one of the founders of the concept of NI and its quantification).

As mentioned just now, producing is adding value. *This value is added to the non-human-made physical surroundings.* Consequently, environmental functions (the most fundamental economic goods at human's disposal) remain outside the measurement of standard NI. This is logical and easy to understand, because water, air, soil, plant and animal species and the life support systems of our planet are not produced by humans. So losses of functions, caused by production and consumption, are correctly not entered as costs. However, expenditures on measures for their restoration and compensation *are* entered as value added. This is asymmetric. These expenditures should be entered as intermediate, as they are costs.

This asymmetry is sometimes defended by the remark that these expenditures contribute to welfare and generate income; see De Haan (2004) and Heertje (2006). This is of course self-evident, counting from the moment at which the loss of environmental functions and the consequential adverse effects have already occurred. However, the production factors, used for the measures, do not add any value counting from the moment that the functions were still available. With respect to that situation there is consequently no increase in (1) the quantity of final goods produced and (2) the availability of environmental functions. Opposite to the income earned with carrying into effect the measures there stays consequently no increase in production volume (= final goods produced) with respect to that situation. Income, to be spend on the market or to be transferred to public authorities, is a claim on goods and services produced by industries and public authorities, it is not a claim on the functions of the non-human-made physical surroundings.

By entering these expenditures as final instead of intermediate, the growth of production is overestimated, thus obscuring what is happening with both environment and production. The information about the development of production is improved by estimating an NI ex asyms alongside the NI. An NI ex asyms, apart from being useful in itself, is also important for the environmentally sustainable national income (eSNI) dealt with in Section 7. The eSNI is above all intended for gauging the distance between the achieved and the sustainable level of production in the course of time. Because expenditure on a number of elimination measures and a great deal of expenditure on repairing damage and on compensation measures are booked as contributions to the NI, NI is not a good yardstick of the (development of the) level of production. During a transition to the sustainable path the distance between NI and eSNI may increase as a result, while the gap between the sustainable and the present level of production (the NI ex asyms), which is what it is all about, decreases. Hence the gap that has to be bridged to achieve a sustainable level of production (the eSNI) is (NI ex asyms – eSNI) and not (NI – eSNI). See De Boer and Hueting (2010) for the formal mathematical details.

With NI ex asyms we remain on the current development path. No changes in behaviour and changes in price ratios are simulated, as is the case with eSNI. So there is no change in the consumption and production package. The asyms can thus be simply deducted. By way of supporting this point it is useful to add: if expenditure on elimination, compensation and restoration of damage *were* entered as costs instead of value added, then one arrives at the same level NI ex asyms as in the case of deduction.

The correct moment of comparison when entering elimination and compensation measures and restoration of damage may be in the same financial year or in an arbitrary year in the past; theoretically that makes no difference. Basically what it boils down to is that neutralising the effects of production growth on the environment must not be regarded as a contribution to the same growth. At the moment disruption in functions of the life support systems through, for example, the emissions of greenhouse gases (which are accumulating and are above the sustainability level), expenditure on elimination measures to reduce these emissions at home and abroad (by buying emission rights), expenditure on measures to compensate for the repercussions of loss of function such as construction of water reservoirs and the raising of dikes, and expenditure on repairing damage resulting from loss of function are partly in different financial years and partly in the same financial year. Disruption of the function 'air for physiological functioning' through intensive use of the function 'air as medium to get rid of waste', for one thing by traffic, and expenditure on medical help for CARA patients to compensate for the repercussions of this, largely take place in the same financial year. The same often applies to the loss of the recreational function of beaches through oil washed ashore and the cleaning up of the oil, a measure to repair the damage because this does not eliminate the cause which is the use of the oceans as a dumping ground for waste.

Asyms are clearly in conflict with the original intention of the creators of NI as an indicator of the fluctuations in the level of the volume of production. Moreover asyms are important for the concept of environmentally sustainable national income (eSNI) dealt with in Section 7. It is therefore a good idea to publish a series of the NI minus asyms alongside the NI series.[2]

7. Second Way: Publish a Series of Environmentally Sustainable National Incomes (eSNI) Alongside the Standard NI's to Indicate the Distance to Environmental Sustainability

Environmentally sustainable national income (eSNI) is defined as the maximal attainable production level by which vital environmental functions remain available for future generations, based on the technology available at the time. Thus the eSNI provides information about the distance between the current and a sustainable situation. The length of the period to bridge this distance, that is the transition period towards a sustainable situation, is limited only by the condition that vital environmental functions must not be damaged irreversibly. In combination with the standard national income (NI), the eSNI indicates whether or not the part of the production that is not based on sustainable use of the environment, is becoming smaller or greater. Because of the precautionary principle, future technological progress is not anticipated in the calculation of eSNI. When constructing a time series of eSNI's, technological progress is measured after the event on the basis of the development of the distance between the eSNI and standard NI over the course of time. When this distance increases, society is drifting farther away from environmental sustainability, if this distance decreases, society is approaching environmental sustainability.

The theory of and the necessary statistics for an eSNI have been worked on since the mid sixties. A first rough estimate of the eSNI for the world by Tinbergen and Hueting (1991/1992) arrives at roughly fifty percent of the production level of the world: the world income. Estimates for The Netherlands by a cooperation of Statistics Netherlands, the Institute of Environmental Studies and the Netherlands Environmental Assessment Agency also arrived at about fifty percent of the production level or national income of The Netherlands; see Verbruggen *et al.* (2001). This corresponds with the production level around

[2] This exercise can be carried out relatively easily because we are talking about actual expenditure so that the NI ex asyms, unlike the eSNI, is on the same development path as the NI. At the time (1970 – 2000) there were those at Statistics Netherlands who were for and against the publication of a series NI ex asyms, and that is probably still the case. As long as the opponents have the upper hand the CE Delft would seem to be the appropriate institute to tackle the estimate of the asyms as a pilot project .

1980. In view of the smaller size of the population, the consumption per capita was by that time substantially higher than fifty percent of the current level. In the period 1990-2005 the distance between NI and eSNI increased by thirteen billion euro or 10%.

The methodology of the present calculation was proposed in 1992 by Hueting *et al*. (1992) and was developed further into the model approach published by Verbruggen *et al.* (2001) and Hueting and De Boer (2001). The necessary condition for sustainability is that environmental functions are maintained for future generations, at the lowest levels of availability that enables the physical elements of the environment, which are the carriers of the functions, to remain supporting these levels. This is the case when the sustainability standards – see Appendix – are met. The data of the cost of the measures to attain the standards and thus maintain vital functions, that rise progressively per unit of function restored (expressed in physical units, see Figure 1), are estimated in the way exposed in Section 4. The model yields an approximation of the eSNI.

The model traces the consequences of (1) the reactions to the change in price ratios (environment burdening activities become relatively more expensive, whereas environmentally benign activities become relatively cheaper) and (2) direct shifts to environmentally less burdening activities. The change in price ratios can be elucidated as follows.

It follows from Hueting (1981) and Hueting *et al*. (1992) that the bulk of national income growth is generated by industries that cause the greatest losses of environmental functions, both in production and in consumption. The increase in productivity in these industries, measured in terms of goods produced, is much greater than elsewhere in the economy, so the real prices of these products decrease strongly, and, with them, the price ratio between environmentally burdening and less burdening products. As a result, any shift to environmentally friendly products has a negative impact on the volume of national income; see Hueting *et al*. (1992). When, as in the simulation of environmentally sustainable income, the cost for attaining environmental sustainability are internalised in the prices of environment burdening products, the real prices of the latter increase, as does the price ratio between environmentally burdening and friendly products. The latter price ratios reflect the situation in an environmentally sustainable situation. *Attaining environmental sustainability without a (drastic) change in price ratios is infeasible*.

The eSNI is the only indicator which (1) is directly comparable with standard NI because it is estimated in accordance with the conventions of the System of National Accounts (SNA), (2) relates the measurable physical environment ('ecology') with subjective preferences (economy) as shown in Figure 1, (3) provides the distance between the actual (NI) and sustainable (eSNI) production level in factor costs and (4) shows the development of this distance in the course of time and thus shows whether or not society is drifting further away from environmental sustainability defined as keeping vital environmental functions available for future generations. Therefore the eSNI is indispensable information for society and policy.

A recent overview of the development of eSNI is given by Colignatus (2008).

8. Third Way: Refute the Fallacy of the Political Statement that Production Must Grow to Finance Safeguarding the Environment

The official policy of all countries in the world is that standard NI - production - must increase in order to create scope for financing environmental conservation, and thus attain sustainability. The theoretical mistake of this reasoning is shown by Hueting (1996). Of course, the future cannot be predicted. But the *plausibility* of the statement can be examined. On the grounds of the data discussed below the statement seems extremely unlikely. The author feels the opposite is more plausible for the following seven reasons.

(1) Theoretically, the possibility cannot be excluded that growth of production and consumption can be combined with restoration and maintenance of environmental quality. However, such combination is highly uncertain and scarcely plausible. It would require technologies that *simultaneously* : (i) are sufficiently clean, (ii) do not deplete renewable natural resources, (iii) find substitutes for non-renewable resources, (iv) leave the soil intact, (v) leave sufficient space for the survival of plant and animal species and (vi) are cheaper in real terms than current available technologies, because if they are more expensive in real terms then growth will be reduced.
Meeting all these six conditions is scarcely conceivable for the whole spectrum of human activities. Especially simultaneously realising both (i) through (v) and (vi), which is a prerequisite for combining production growth and conservation of the environment, is extremely difficult. Anyhow, technologies necessary for the combination of production growth and full conservation of the functions of the environment are not yet available. Anticipating the future availability of such technologies conflicts with the precautionary principle, and consequently with sustainability, which is, of course, certainly not the same as forecasting or not expecting technological progress.

(2) An analysis of the basic source material of the Dutch national accounts shows that roughly one third of the activities making up standard NI (measured as labour volume) do not contribute to its growth. These activities include governance, the administration of justice and most cultural activities. Part of the services sector contributes moderately to the growth of NI, while the remaining one third contributes by far the largest part to the growth of production. Unfortunately, this latter third consists of activities associated with production and consumption that cause the greatest damage to the environment in terms of loss of nature and biodiversity (by use and fragmentation of space), pollution and depletion of resources. These activities include the oil and petrochemical industries, agriculture, public utilities, road construction and mining. These results are almost certainly valid for other industrialised countries and probably valid for developing countries; see Hueting (1981) and Hueting et al. (1992).

(3) The burden on the environment as represented in standard NI equals the product of the number of people and the volume of the activities per person. Reducing this burden by decreasing population lowers growth or leads to a lower production level.

(4) Applying technical measures has a negative effect on growth of production because they enhance real prices: more labour is needed for the same product. The research for the estimates of eSNIs has shown that environmental sustainability cannot be attained solely by applying technology. In addition, direct shifts, such as from car to bicycle and public transport, and from meat to beans, also are necessary. From point (2) above it follows that these shifts also reduce growth or lead to a lower production level.
(5) A price rise resulting from internalising the costs of the measures which restore the environment means, like any price rise in real terms, a lowering of production growth. Depending on the situation, this decreases the production level. For a given technology, product costs will rise progressively as the yield (or effect) of environmental measures is increased. Of course, technological progress leads to higher yields. As production increases further, however, so must the yield of the measures increase in order to maintain the same state of the environment, while the fact of progressively rising costs with rising yields remains unaltered.
(6) An unknown part of the value added in standard NI consists of asymmetric entering (see Section 6) and should therefore not be considered as a contribution to its volume, see Hueting (1974/1980). This part will increase considerably because of the expenditures on (1) measures to eliminate the origin of the climate problem (caused by damaging the functions of life support systems due to production growth) by reducing the emission of greenhouse gases and on (2) measures to compensate the effects of climate change, e.g. by building dikes and moving to higher elevations.
(7) A sustainable production level with available technology is about fifty percent lower than the current level, both for the world: see Tinbergen and Hueting (1991/1992) and for the Netherlands: see Verbruggen et al. (2001). From this it follows that eSNI has to grow more than twice as fast as NI in order to reduce the distance between NI and eSNI. This seems to be an almost impossible task for environmental technology, which is the only means for increasing eSNI.

9. Fourth Way: Clarify Why Environment Does not Conflict with Employment under Logical Conditions

The proposition that to preserve the environment we must sacrifice employment is probably the major obstacle standing in the way of a sound environmental policy. This is because the proposition overlooks the simple fact that the possible uses or functions of the environment (including natural resources) are scarce goods which require the use of production factors for their restoration, preservation and substitution. Of these, labour is the most important. For example, in the Netherlands more than 80% of the Net Domestic Product is labour income (including mixed income - i.e. income of industries that goes to private households). In macroeconomic terms, labour is the dominant cost factor. *A given amount of production and consumption requires more labour with environmental conservation than without.* The extra labour required is used to maintain scarce environmental functions. [3]

[3] Conventional labour productivity, whereby the loss of scarce environmental functions is not taken into account, is therefore declining.

This conclusion can be elucidated as follows.

Human beings ultimately depend on three factors for survival and for the level of consumption that they want to attain:

- the possible uses, or functions, of their physical surroundings, the environment: water, air, soil, plant and animal species, space, and natural resources, including energy resources;
- ‘hands and brains’ - in other words, labour, and because the brain steers the hands, it is ultimately human ingenuity that counts;
- time.

Of course, capital is also a production factor. But capital goods are manufactured by labour, using elements of our physical surroundings: the environment. Ultimately, the environment, labour and time are the factors with which humans have to make do in obtaining what they need.

The environmental problem can be conceived as a process involving the steady substitution of time, or working hours, through depletion of the environment. For example, spraying herbicides requires less time than manual weeding. The point made in italics above can therefore be reformulated as follows: given the technology available at a given time, it takes more time, that is working hours, to attain a certain goal without depleting the environment than if the environment is depleted.

There is a continuous exchange between the time spent on work with that on leisure. Working hours are reduced either directly or by longer holidays and part-time work. On the other hand, there is an increase in working hours owing to the participation of women, and all kinds of small jobs on the side. Leisure and working hours can be substituted [4] once a basic level of self-support has been reached. So the point can again be reformulated as follows: *attaining a certain goal requires more labour with environmental conservation than without.*[5]

Travel provides a clear example of the exchange between time and the environment, both in production and consumption, and also of the potential for substituting time for work by time for consumption. A newspaper reporter can interview three international ‘personalities’ a week by travelling by airplane, and perhaps one by taking the boat or train. The same holds true for consumption: we can reach more distant places if we travel in ways that burden the environment than if we do so in environmentally friendly ways.

As a society, [6] we have the following three choices:

- *First choice*: From this day on we take the train to a nearby resort, instead of taking a plane halfway round the world to Bali. This means a lower level of welfare acquired from goods produced, because the new consumption pattern differs from revealed preferences. It also means a lower real national income, because activities with a

[4] The degree of substitution and its direction obviously depend on preferences. Decisions on this point can usually be made individually.

[5] Whatever goal, whether travelling or producing meat.

[6] Environmental functions are collective goods. Individual decisions are subject to the prisoner's dilemma. Within a given structure, one puts oneself at great disadvantage while the desired effect is estimated to be negligibly small because one doubts whether others will join the effort. This is why a choice can only be made collectively.

capacity for producing a volume of goods that has increased to fabulous heights in recent decades are replaced by activities for which this capacity has increased only modestly, or not at all (see Section 8).

- *Second choice*: We continue going to Bali, but we do so by train and boat. This means an increase in travel time, less time for work and consequently lower consumption. A lower volume of national income accrues due both to the lower labour productivity of the transporters and to shorter working hours for the traveller.
- *Third choice*: We continue flying to Bali and accept the inherent loss of the environment.

With the current state of technology it is impossible to realize existing levels of production and consumption sustainably.[7] As long as this is the case, we can only increase our production and consumption (per time unit) at the expense of the environment (see Section 3 and 8). The extra labour needed to save the environment is either directly or, on balance, the result of environmental protection.

Clean production and consumption require provisions and adaptations of all kinds. Examples include cleaning industrial or household waste water, integrated pest control in agriculture, sustainable exploitation of forests, and prevention of noise nuisance. Such provisions and adaptations require more labour *directly.*

In the case of activities that burden the environment being replaced by environmentally less burdensome activities, there is always a *positive balance* of additional labour and saved labour. Besides travel (see above) packing is a clear example. Disposable packaging and cutlery were introduced to reduce labour input in order to increase labour productivity. However, the ensuing loss of scarce environmental functions is not taken into account in the calculation of this productivity. If we buy eggs in a basket, milk in a jug and take-away Indonesian food in a rantang, we will certainly cause some loss of employment in the packaging industry, but at the same time we create many more jobs in the service sector. This too results in a decrease in labour productivity: the same goal is reached with more working hours and more consumer time. In the past, the price mechanism forced out labour at the expense of the environment because the environment falls outside this mechanism. This labour will be drawn in again when we start taking the environment into account in whatever form by ‘internalising’ it (again, given the available technology).

The absurdity of a perceived conflict between the environment and employment becomes particularly evident when we trace its consequences. If conservation of the environment were to be achieved at the expense of employment, then ‘clean’ production and consumption should require less time than ‘dirty’ production and consumption. Because labour is the dominant cost factor, as explained above, clean production would then be cheaper. From this it follows that there would then be no environmental problem! Everyone would then switch to these cleaner, cheaper production methods, forced to do so by the market. Thus, if merely one company were to switch to clean production, the rest would have to follow suit in order not to be priced out of the market.

The situation is presented upside down: the opposite of what we are being told is true. There is an environmental problem because clean production creates structurally more

[7] This appears from the study on sustainable national income described in Section 7.

employment than dirty production. This makes clean products more expensive, and this is why we produce and consume in a way that burdens the environment. [8]

The environment is a collective good, and decisions about it can only be made collectively. If one company switches to production methods that meet national or global sustainability standards, while others do not follow suit, then higher costs will price that company out of the market, and disemploy its employees. Therefore, the logical conditions under which regaining the availability of environmental functions that have become scarce goods creates rather than destroys employment must be made binding for the whole economy. Of the necessary preconditions the following are the most obvious:

1. Income has to be reduced in proportion to the costs of the measures required to conserve the environment. This precondition is completely logical. The extra labour required to restore and conserve scarce environmental functions is deployed to acquire non-market goods. Since income is nothing but a claim to produced goods (the sum of incomes equals the sum of goods produced), environmental measures come down to a reduction of (the growth of) the wage base. This outcome corresponds with an extremely simple datum. A good is scarce if one needs to sacrifice something else that one would like to have in order to acquire it. With scarce goods it therefore holds that more of the one entails less of the other. Thus, *ceteris paribus* (including the technology available at a given moment), more environment means less production and vice versa. The conflict is therefore apparently between the environment and production or its growth, rather than between the environment and employment.
2. Other countries must take similar measures to the same degree. This precondition is logical too, because otherwise firms from countries without protection measures can compete domestic industries out of the market.

It is difficult if not impossible to test the effects of the introduction of these conditions empirically. The environmental measures taken to date are marginal in relation to what has to be done to arrive at a sustainable use of the environment. Most measures only slow down the rate of deterioration, owing to the persistent and cumulative character of the burden. No government in the world accepts the unavoidable truth that, given the available technology, more environment means less production (and vice versa); so nowhere is reducing the wage rate taken in consideration.

However, the introduction of the necessary preconditions *can* be simulated and their effects *can* be tested with the aid of an econometric model. This has been done in the CE-scenario (Potma et al., 1983). A summary in English is given in Hueting (1987). In this study two contrasting scenarios are elaborated, one with business as usual and one giving priority to saving the environment and resources, be it not up to environmental sustainability . All

[8] The point is whether or not we want to 'pay' for environmental conservation in the form of re-allocating production factors for the implementation of technical provisions or in the form of a direct shift from environmentally burdening to environmentally friendly activities. Examples: from car to bicycle, from a lot of meat to a little meat plus beans. There is no way to establish unambiguously what sacrifices we are prepared to make to preserve the environment (see Section 4).

variables that are not relevant to the problem are kept the same. In this way the effects of environmental protection on employment and production are isolated. In the environment scenario, wages are reduced in proportion to the costs of the measures taken, but similar measures in other countries are not assumed. Still, the outcome of this model study confirms what can be expected on the grounds of simple analysis: unemployment decreases [9] and production growth is checked (if the outcome of a model is not in conformity with the underlying theory, one of the two has to be reconsidered).

One of the underlying assumptions of the model study is that the demand for goods and services produced remains fully intact. For example, people have been travelling from time immemorial; they will not stay at home if car and air traffic decreases; they will go by train, boat or bicycle, even though they do not get as far per unit of time; the revealed preference for travel will not suddenly disappear.

The enormous concern voiced by governments and industry about environmental issues would lead one to expect major encouragement of research on the logical conditions under which two major issues of our time - unemployment and the environment - neutralize rather than reinforce one another. But nothing could be further from the truth. The above-mentioned CE-scenario has been completely ignored.

Openly admitting the above obvious fact and creating the logical conditions under which the problems of unemployment and the environment neutralize one another would lead to a structural drop in labour productivity. This certainly checks the growth of production as measured in national income, and probably leads to a lower production level. With this conclusion we have arrived at the heart of the environmental problem - growth of production (see Section 8).

10. FIFTHS WAY: SHOW THE WRONGNESS OF THE STATEMENT THAT ENVIRONMENTAL CONSERVATION IS UNPAYABLE

We would love to save the environment, but it is too expensive. This statement may not be the most dangerous one, compared with the wrong statements mentioned above, but it is certainly the most hypocritical. All fundamental solutions for safeguarding the environment are clearly much cheaper [10] than continuing the process that is threatening life on this planet.

For example: travelling by bicycle is much cheaper than driving the same distance by car. Heating one room, in combination with a sweater and an extra blanket, is much cheaper than heating the entire house. A vacation by boat or train is cheaper than a holiday flight. A diet combining some meat and beans is cheaper than eating lots of meat. Winter vegetables in winter are cheaper than summer vegetables in winter. Raising two children is cheaper than raising six.

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[9] Of course, seasonal, frictional and business-cycle unemployment are not influenced, nor the unemployment caused by the fact that labour productivity is lower than the legal minimum wage.

[10] Cheaper in the ordinary everyday meaning of the word—that is, in the sense that less input of production factors is required. Compare footnote 8.

The burden on the environment is determined by the number of people, the amount of activity per person, and the nature of this activity. Because activities with little or no impact on the environment can be expanded, the shift to environmental sustainability comes down to adapting the number of individuals of our species and the kind of activities we engage in to the carrying capacity of our planet. This adaptation is extraordinarily cheap.

Of course, there is an economic sacrifice to be made; otherwise there would be no environmental problem. Most of us would love to make unrestricted use of the private car, are mad about eating meat, and prefer to have sex without a pill or condom. But if we unlink our credo of progress from the growth of our consumption, there is no reason at all to panic. In the first place, shifting to sustainability will not damage our health. On the contrary, environmentally-friendly activities are usually healthier than those that harm the environment. Second, a sustainable level of activity by no means implies a return to the Middle Ages, as often claimed. Global production and consumption will have to be halved in order to attain sustainable levels (see Section 7), thus to repay our debt to future generations. In the long term NI doubles every 25 years. Were living conditions in 1985 worse for most of the people in the world than they are now? A sustainable level of activity will be higher than that of 25 years ago.

11. Appendix About Standards

In establishing sustainability standards, as the basic point of departure is taken the natural regeneration capacity of the environment: as long as this remains intact, environmental functions will remain available. The following examples illustrate how this quantity and the acceptable, that is sustainable burden can be established. It can, for instance, be established that the rate of erosion of topsoil may not exceed the rate of formation of such soil due to weathering. Similar consumption standards can be set for other natural resources. With respect to how sustainability relates to species, then, the standard holds that the rate of human-induced extinction should not exceed the rate at which new species come into existence. This boils down to preserving all the species still alive today, for it is assumed that during the past several thousand years conditions have been such that, leaving aside drastic human intervention for the moment, the number of new species must certainly have at least equalled the number of species lost to extinction (Raup, 1986; Hawksworth, 1995). However, in contrast to the situation prior to human intervention, the rate at which natural species are becoming extinct is today at least a factor 10000 higher than the rate at which new species are evolving (Raup, 1986). There is obviously a level, defined as a number of individuals of a species, below which the species is threatened with extinction; arriving below that level is unsustainable, remaining above that level is sustainable. Together with the condition that harvesting a species should not disrupt the ecosystem of which it forms a part (see Odum, 1971), this yields the sustainability standard for the species. In the absence of drastic human intervention, the quantity and quality of renewable natural resources such as groundwater or biomass (including wood) generally show a substantial degree of constancy. In the absence of human intervention, our renewable physical surroundings is thus characterized by a substantial degree of constancy or even increase.

With regard to pollution, too, criteria can be established (Hueting and Reijnders, 1996, 1998). Acid precipitation, for example, should not exceed the neutralizing capacity of the soil. Likewise, there should be no exportation of risks to future generations through pollution of groundwater that is to serve as a source of drinking water for those generations. In many cases, the accompanying environmental burden can be determined with great accuracy. There is a wealth of data on the rate at which new fertile soil is naturally formed and on the neutralizing capacity of natural soils, and these data enable a precise indication to be given of the admissible environmental burden due to erosion and acid rain (Reijnders, 1996). In other cases we have insufficient knowledge to make firm pronouncements. For example, at present we can do no more than give a rough indication of the conditions under which plant and animal species are able to survive (Hawksworth, 1995; Den Boer, 1979). On the basis of the best available global circulation models it can be calculated that worldwide emissions of carbon dioxide must be reduced drastically to achieve stabilization of the global warming process, but an exact percentage cannot be given (de Boer, 1996). Similarly, shortcomings in our toxicological knowledge mean that we cannot fully analyse the risks associated with polluted groundwater. However, this does not detract from the fact that improved scientific knowledge can lead to a more precise establishment of standards for sustainability.

All in all, it is feasible to establish scientifically the environmental burden that is 'admissible' on the basis of the objective of sustainability. Hueting and Reijnders (1999) describe how the precautionary principle can be employed if there are uncertainties and inadequate knowledge in the context of sustainability.

In the case of very slowly forming natural resources such as crude oil and copper, which are to all intents and purposes non-renewable, 'regeneration' can take three forms: efficiency improvements, recycling and, over the longer term, substitution of one form of environmental element by another that can provide the same functions. Familiar examples of substitution include solar power and glass fibre for crude oil and copper wire, respectively.

This can be expressed as follows in a numerical value. Sustainability of non-renewable natural resources means that in a given period only as much may be withdrawn from the stock as substitutes for the resource are expected to be developed in the long run as well as new potential for recycling and conserving the resource (improvement of efficiency). In this way the functions of a resource available in the year of investigation are maintained at the same levels in the future. In practice this can be worked out by, for instance, taking from a period in the past the quantity of possible uses (for example heating, transportation, and so on expressed in effective energy) that has become available through efficiency improvement, substitution and recycling and then assuming that the relative rates of efficiency improvement, substitution and recycling will be the same in the future.[11] There follows from this a maximum permissible annual rate of extraction that can be used as a sustainability standard. In a formula: $e(t_0) \leq r(t_0).S(t_0)$, in which $e(t_0)$ is the extraction rate in year t_0, $r(t_0)$ the relative rate (or rate coefficient) of reduction of consumption of the resource (resulting from substitution, and so on) at *a constant level of activities,* and $S(t_0)$ the stock in year t_0 (Tinbergen, 1990).

[11] This involves an assumption about technological progress in the fields of substitutes and recycling. This exception to the point of departure that the estimation should be based on the technology that is operational in the year of investigation, or shortly thereafter, is the only way to arrive at a sustainability standard for non-renewable resources. The only other option, to pass on stocks untouched to future generations, is unfeasible and also makes no sense, because this would then have to be carried through *ad infinitum.*

This formula is applied at the global level. Standards for individual countries can be subsequently derived by applying the general rule that a country's share in meeting the global standard should be equal to its share in total extraction.

In practice, the factor $r(t_0)$ is determined mainly by efficiency improvements, as substitution and recycling have still made only a very minor contribution in recent years. The aforementioned assumption that the line recording use of the resource in the past can be continued into the future with, basically, a constant annual rate of efficiency improvement, implies that as time progresses the same material output can be achieved at a fraction of current resource use. In a study on the development of energy efficiency, Tinbergen (1990) found a practical value of 1.67 per cent for this improvement rate. From this it follows that in 60 years' time the *present level of production* can be achieved with 37 per cent and in 315 years' time with 0.5 per cent of current fossil fuel consumption: $S(315) = (1-0.0167)^{315} \times S(0) = 0.005 \times S(0)$. Such enormous efficiency improvements (63 per cent and 99.5 per cent, respectively) seem rather unlikely. In the context of sustainability, 315 years is a very short time. The probability that humankind will sooner or later have to manage without the functions of the non-renewable natural resources, if no substitutes are found, is comparable to the certainty that humankind will sooner or later have to manage without the functions of the soil in those areas where the degree of erosion is higher than the rate of soil formation.

Because efficiency improvements alone are thus inadequate to achieve sustainability, it has been proposed in the theory behind the calculation of eSNI, that additional measures must be taken for the development of substitutes (Tinbergen and Hueting, 1991). We here adopt this proposal, applying the following procedure. For each resource, statistical data are used to establish the rate at which substitution (the ultimate solution) has taken place over the past 10 to 20 years and the annual cost this has entailed. It is then calculated how long it would take, at this rate, to completely replace the resource (1). Next, it is calculated how long it will take for the resource to be depleted, at the *current* level of production (2). Then (1) divided by (2) yields a rough approximation of the required ‘acceleration factor’ for the development of substitutes in time for them to replace the functions of the resource when it is depleted. This factor multiplied by the statistically established annual cost of substitute development yields the sum that needs to be reserved for this purpose.

The figures thus found can be no more than rough estimates, of course. In the context of non-renewable natural resources, though, this is an approach that does justice to the principle of sustainability, which is the point of departure of our estimates. Our approach would be comparable with that of Solow (1974), Hartwick (1977, 1978) and others, if the latter were to exclude unfeasible substitution of renewable resources by other resources and by capital (see below), that is if they were to abandon their faith in the extreme areas of formal production functions.

When using the concept of environmental function, the only thing that matters in the context of sustainability is that vital functions remain available. What does the conservation of vital functions imply for the distinction between renewable and non-renewable resources and for the distinction between strong and weak sustainability?

As for renewable resources, functions remain available as long as their regenerative capacity remains intact. Regeneration in relation to current use of ‘non-renewable’ resources such as crude oil and copper that are formed by slow geological processes is close to zero. ‘Regeneration’ then takes the form of efficiency improvement, recycling and, in the final instance, developing substitutes (see above). The possibilities for this are hopeful (Reijnders, 1996; Brown et al., 1998). So, economically speaking, there seems to be no essential difference between the two types of resource: sustainability is attained if their functions remain available.

Advocates of 'weak sustainability' take the line that all elements of the environment can ultimately be substituted by man-made alternatives, implying that restoration of lost elements can be postponed in anticipation of cheaper substitutes provided by future technologies. However, the life support systems of our planet (see Section 3), on which a number of vital functions depend, are not substitutable at all (Lovelock, 1979; Roberts, 1988; Goodland, 1995; Reijnders, 1996). The same holds for most of the functions of natural ecosystems, especially in the long term (see, for example, the remark on the function of 'gene pool' in Section 3). Consequently, there can be no such thing as 'weak sustainability' for the functions of these systems.

Advocates of 'strong sustainability' hold it to be impossible for humanity to substitute many of the elements of the natural environment. In its strictest form, however, this implies that stocks of non-renewable resources should remain fully intact, an unrealistic aim. Consequently, strong sustainability for non-renewable resources seems to be impossible.

In conclusion, there seems to be only one kind of sustainability, whereby non-renewable resources must gradually be substituted by other elements of our physical surroundings in order to guarantee the availability of functions, and substitution of a large class of renewable resources is impossible, particularly life support systems, including ecosystems.

The question is often asked whether sustainability standards should be applied locally or globally. This depends on the scale at which the functions in question should be substituted. For instance, preservation of the function 'soil for growing crops' requires local application of the standard for erosion (the erosion rate may not exceed the soil formation rate; see above), because exceeding the standard at one place cannot be compensated by remaining under this standard elsewhere. Crude oil, on the other hand, is a global resource, so in this case the sustainability standard, effectuated through efficiency improvement and substitute development, should be applied worldwide.

12. Conclusion and Recommendation

The arguments given above lead to the following conclusion and recommendation.

1. Our planet is threatened by a wrong belief in a wrongly formulated growth.
2. The NIs (or GDPs) in all countries should be supplemented by a series of NIs without asyms and a series of eSNIs, alongside the standard NI, in order to improve the information.

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