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Adapting the Environmental-Economic Standard Model to Sustainability Analysis

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Applying Ecological Economics for Social and Environmental Sustainability

Abstract

Economic sustainability analysis is often difficult because the assumptions about the natural environment and how it is valuable to society are in conflict with standard assumptions in the other academic disciplines involved in analysis of environmental sustainability. This is because the same model that is developed for analysis of consumer behaviour in standard commodity markets is transferred with few adaptations to the problem of environmental choice. This model is the standard neoclassical model for optimal pollution or optimal pollution control and serves as the "pre-analytic vision" for analyses of such problems. In several respects the standard assumptions in the model conflict with the standard assumptions in other academic disciplines such as physics, biology, psychology, and political science. These flaws of the model can lead to dismissal of analysing the issue of optimality at all in analysis of environmental problems.

The paper suggests a number of adaptations, which when used as a starting point for economic analysis will make it more frictionless in sustainability analysis. They include the efficiency gap and dynamic economies of scale in the abatement function, threshold values and irreversible flip-over in the damage function, and lexicographic preferences in the social cost function. A more elaborated standard model along these lines reflects to a high degree the real choices made in environmental policies in Europe and it could serve as a more useful "pre-analytic vision" for analyses with an economic approach as well as for analyses with an ecological approach. The paper concludes that the problem of inconsistencies in standard assumptions in the interdisciplinary analysis is better solved by harmonising the assumptions than by excluding economics from the analysis.

Contents:

Sustaining Capital, Nature, and Natural Capital

The concept of sustainability is fundamental in economics. Red numbers at the bottom line signal that an economic activity is not financially sustainable.

The most frequently answered question in economics is whether it pays to carry through a particular economic activity. Whether it is better to use the scarce resources for that purpose rather than for another purpose. When the social costs of consuming or producing something exceed the benefits, it is not only irrational to do it. It will not contribute to sustaining the current level of welfare.

This way of thinking is directly transferable to questions of environmental sustainability.

In fisheries and forest economics the economic analysis searches for efficiency within the sustainable harvest. A sustainable harvest is less than or equal to the natural growth of the resource, which is an intuitive condition for sustaining the resource stock. Sustainability requires maintenance of a balance between additions and extractions.

Exhaustible resources don't grow and attention was drawn to the question of how to sustain production in which exhaustible resources are indispensable in the 1970s contributing to the so called Great Debate on economic growth on a finite planet. Seminal papers presented at a Symposium on the matter in 1974 included among others Solow (1974), Stiglitz (1974), and Dasgupta and Heal (1974). The answer to the question was to invest the proceeds from the resource in manmade capital – later on pinned out in the "Hartwick rule" (Hartwick (1977)) - and increased productivity. The fundamental assumption is that you can substitute natural resources by manmade capital in still larger proportions. Therefore the economy can always make up for dwindling natural resources by investing some of the value gained from the use of them.

This sustainability criterion was extended to include the destruction of environmental qualities in numerous papers such as Hartwick (1994). The assumption of perfect frictionless substitution of environmental values by economic values was already by then frequently used in cost-benefit-analysis. Often with reference to a notion that this was the only way environmental values could be taken into account at all. The damage caused by the environmental pressure was assumed to be quantifiable in units and the value of environmental qualities to society was supposed to be definable in terms of the monetary value of these units. With this assumption of unconditional substitutability it is easy to express sustainability in terms of the Hartwick rule.

It is, however, intuitively easy to unveil that this line of sustainability is too simplistic. According to this sustainability criterion, it would be sustainable development to let all the ground water reserves be poisoned by pesticides and other chemicals if we at the same time invested in a sufficient amount of highways. Such a development would, however, fit into few people's conception of sustainability. It is certainly not a very useful approach in interdisciplinary research where such a sustainability criterion would neglect the sustainability criteria from the perspectives of any other academic discipline.

Thus, the Hartwick rule had to be developed further to be able to contribute to interdisciplinary research in sustainability. Pearce and Turner. (1991) characterised the Hartwick rule as "weak sustainability". A "strong sustainability" criterion would include what they labelled as "critical capital". Critical capital is natural capital stocks that are not substitutable. Maintaining this stock of capital is the strong criterion for sustainability. The question of weak versus strong sustainability is discussed at length in Neumayer (2003) and Atkinson, Dietz et al. (2007).

But what does it mean to maintain this stock? Should the each identified important piece of nature that now has been identified be maintained or should the sum of the value of all these pieces of nature be maintained? The question arises because of different conceptualisations of the term “natural capital”.

In the context of economics, the term expresses the core assumption of economic analysis that a lot of important goods and claims eventually can be reduced to a monetary value. They are substitutable as economic assets. This assumption helps enormously in identifying rational actions in the sense of actions that brings more than they consume.

In an ecological context, however, natural capital is a metaphor for pieces of nature that provide valuable, but often very complex conditions for economic activities. If the “stock” is reduced, its “returns” are reduced as well. The point of the metaphor is that it is important to care for the stock if you want the returns just as it is in economic issues. The metaphor is, however, limited by the impossibility of expressing the “returns” as a single percentage figure in most cases. It is simply too complex. The functions of particular environmental qualities or resources may not be substitutable at all although they are substitutable as economic values.

There is also some confusion about what you should understand about “critical”. In some approaches, it is specific types of nature such as the ozone layer, genetic diversity, and unspoiled rain forests. When we go deeper into the environmental problems it very soon becomes clear, that we cannot consider any type of nature as “sacred” *per se*. What we can say is critical is a certain minimum level of any type of nature. The ozone layer has to be of a certain “thickness” to absorb and thereby protect us against solar radiation of harmful wavelengths. The greenhouse gas concentration in the atmosphere needs a minimum permeability for outgoing heat radiation from the earth to curb the global warming to a level that is consistent with maintaining of the fundamental energy balances of the planet to which current life at earth has adapted.

De Groot, Van der Perk et al. (2003) review a range of definitions of critical capital and find that critical capital in any case is characterised by its *importance* and the *threat* to its existence. It takes a multitude of socioeconomic and ecological criteria to describe its importance and the threat to its existence is a matter of future sustainability as well as more immediate threats. In a series of other contributions Ekins (2003; Ekins, Folke et al. (2003; Ekins and Simon (2003; Ekins, Simon et al. (2003) suggest to identify critical natural capital starting from predefined sustainability standards and identifying the resource qualities and quantities necessary for maintaining these standards.

Following these insights, the sustainability standards assume the decisive role in defining what is sustainable. It is, indeed, a political question what we want to sustain, but still there is a need for more scientific insight in the limits as to what nature and humans can take. This paper maintains the fundamental position that it is a political question what we want to sustain, but adds to it the possibility of science and insights in society and humans to identify thresholds beyond which the effects become unacceptable. The role of such thresholds in defining what is critical is ambiguous in the above mentioned literature.

The critical capital that society wants to maintain is not just a quantity of homogenous capital-porridge, but an extremely diverse and complex set of environmental qualities and balances. Then we need answers to which environmental qualities we want to maintain within which limits before we can give answers to whether development is sustainable. Neither science, nor economics are capable of giving such answers, yet they both have a role in framing the question as illustrated below. It is very much a political or collective task to identify these “targeted” qualities, but insights from economics and science of course are crucial to this end.

On the other hand, growing or non-declining consumption opportunities are still important for development at all, sustainable or not. Therefore, there is a role to play for a “weak” sustainability criterion. The productive capacity of a national economy does not necessarily depend strongly on environmental qualities but natural resources such as oil and natural gas are, of course, important factors in formation of gross national income. The national and global aspects of this are treated in Hansen (2002) whereas this paper will focus on the analysis of environmental sustainability

The standard environmental-economic model used in mainstream economics reflects by and large the collective deliberations that enter a rational decision-making process. However, when based on very simplistic assumptions about nature, the policy cycle, psychology, and technology it often meets hard resistance from the involved disciplines. This incompatibility of assumptions, of course, is devastating for attempts to reach further conclusions through interdisciplinary research. This paper is about how to adapt these assumptions to the facts that are known in these disciplines in order to develop the compatibility required for interdisciplinary research.

The rest of the paper is organised as follows. The standard model for balancing environmental and economic objectives is presented in the following section. Then the paper compares the assumptions behind the model one by one with the standard assumptions typically made in the respective disciplines. Finally, the usefulness of such an approach to economic analysis is discussed.

Standard Assumptions in the Mainstream Economic Standard Model

Analysing the behaviour of agents on a market involves the fundamental economic problem of what is the most beneficial level of consumption of alternative goods. We prefer to consume more rather than less of any good at the market, but as we do it we must consume less of other goods because we have scarce resource to produce them from. The standard model developed to analyse this problem take advantage of the general feature of the commodity space available to the consumer. Thousands of varieties of thousands of commodities are displayed on the shelves in the malls. They are different, but for each of them, it is easy to find close substitutes. It is not unrealistic to assume that you could arrange them all in a line where each of the commodities is neighboured by close substitutes. Thus, it is realistic to assume substitutability within very wide ranges. An average trolley worth a €100 can be filled in a million ways so that it satisfies our needs, but always so that more of one commodity means less of other commodities.

The standard model of consumer behaviour reflects this concept of marginal changes in the composition of the average trolley with plenty of room for variation without neglecting our basic needs. It does so by assuming continuous and double differentiable functions transforming smoothly between the benefits and costs of an additional item.

It is this methodological approach that builds the basis for the standard environmental-economic model in mainstream economics. The problem is that the assumptions about substitutability, decision making, etc. that are useful simplifications in modelling the consumer in the mall are not very good in modelling of environmental policy making.

There is a trade-off in environmental planning between environmental qualities and consumption opportunities and this trade-off has a lot in common with the trade-off faced by the consumer in the mall, but it is not exactly the same. Let us start by examining the environmental-economic standard model.

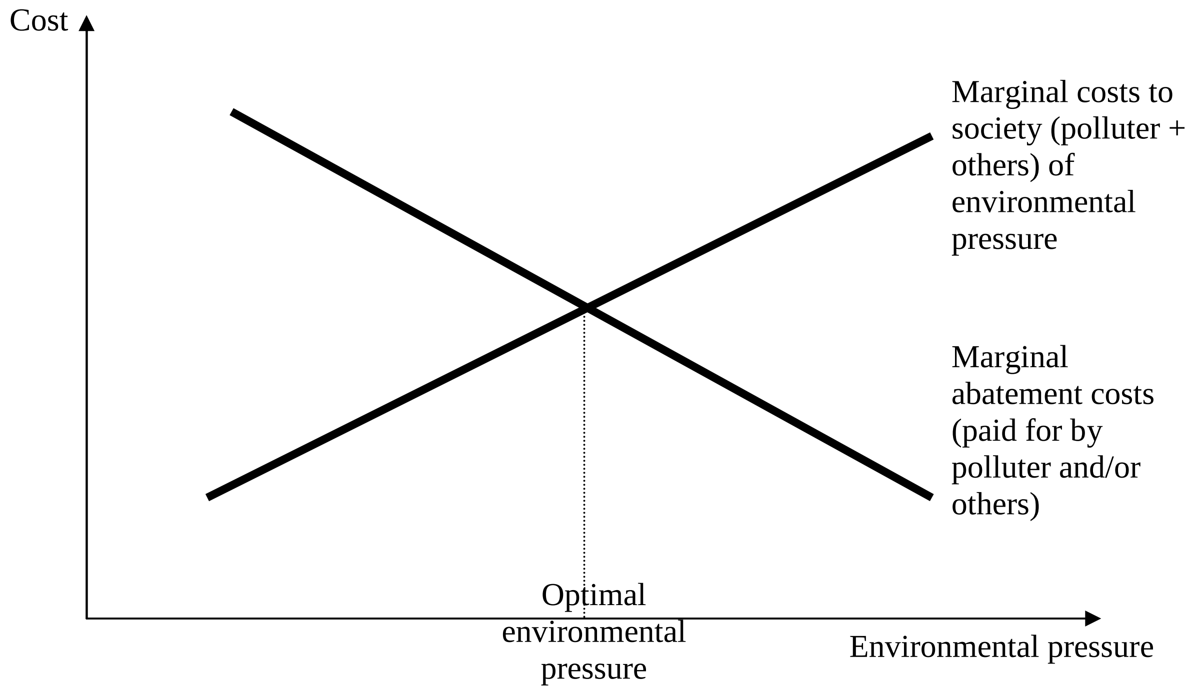
The analysis of environmental-economic trade-offs must obviously be separated in an analysis of the physical causalities and the value of the physical changes. Whereas the latter is a matter for social science to which we will return below, physical causalities are exclusively the domain of science and technology.

In the standard model, the loss to society of an additional "unit" of environment is assumed to be increasing as more and more of the environment is lost. The marginal cost of pollution is assumed to be increasing. Or, put differently, the value of an additional unit of environment is lower the more units of environment we consume in advance, just as is the case for consumer goods.

At the same time the cost to society of preventing a loss of an additional unit of environment is assumed to be increasing. The marginal abatement costs are increasing with increasing abatement and therefore decreasing with increasing pollution. Pollution is assumed to be monotonically reflected by the reverse scale of abatement.

These two assumptions implies that there must be a balance where an additional unit of environment is exactly as much worth to us as it costs to maintain it. This is the socially optimal level of pollution or environmental pressure on the one side and of the pollution abatement efforts at the other side.

Figure 1. The Mainstream Economic Standard Model of the Trade-off between Environment and Consumption Opportunities.



These assumptions suffice for the existence of a unique optimum and the economic problem can conveniently be formulated in a mathematical optimisation problem with a unique solution. The uniqueness of the optimal environmental pressure can easily be understood intuitively. To the left of the optimal environmental pressure, the abatement costs that can be saved exceed the costs to society of allowing an extra unit of environmental pressure. Thus, on balance it pays to allow it. To the right, the opposite is the case. The cost of abating and extra unit of environmental pressure is less than the environmental gains of doing it. Thus, all costs added will be less by doing it.

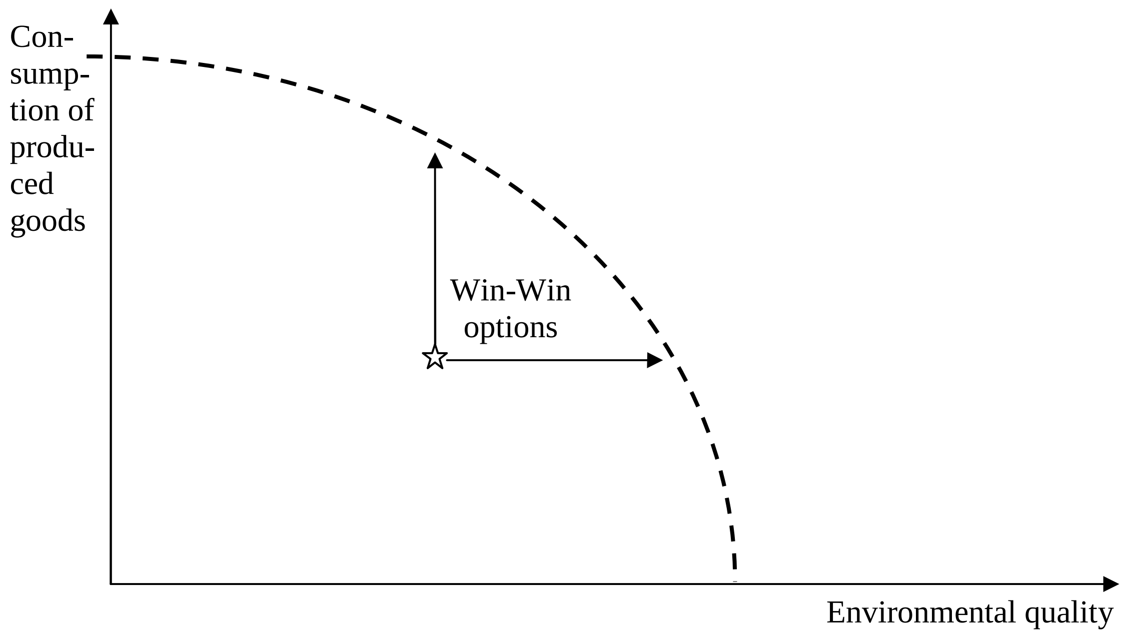
In the following we will examine the individual components of this model one by one. First, we examine the abatement cost function. Second, we examine the social costs of environmental pressure or lost environmental quality. According to the logic of the model these can be decomposed into a damage function describing how the natural environment reacts to environmental pressure and a valuation function describing how society value the natural environment. Obviously, it is necessary that the natural environment can be described by some sort of quality index. The damage unction and the valuation function will be discussed separately.

The Abatement Function

The abatement function links abatement activities with the economic costs of undertaking them. Abatement can be any action that helps reducing environmental pressure. It could be end-of-pipe solutions such as installing filters or changes in technology used such as raw materials with less harmful waste products. Or just to use more attention and manpower to be careful not to let harmful wastes into nature, possibly even recycle them. In any case, it is assumed that on the scale of the aggregate economy production must be less than without the abatement because of the capital and labour devoted to abatement rather than to production.

Thus the fundamental assumption behind the standard model is that society faces a trade-off between consumption opportunities (= production = income) and environmental quality. This is represented by the curve in the figure below.

Figure 2. The Trade-Off between Produced Goods and Environmental Quality.



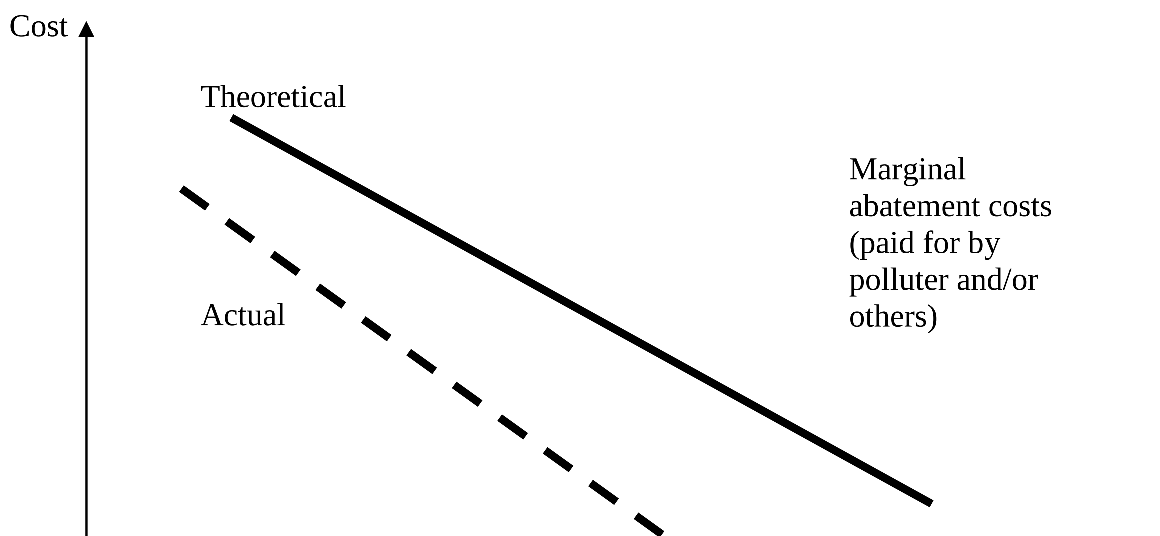
The curve describes the combinations of consumption of produced goods and environmental quality that are possible. Every point inside and on the curve are possible, but the points inside the curve – such as that represented by star - are inefficient in the sense that it is possible to consume more produced goods or get a better environmental quality or both. Only points at the curve represent a trade-off in the sense that you cannot get more of one good without sacrificing some of the other good.

In economic analyses it is routinely assumed that all production is efficient and environmental economics is no exception. Everybody are supposed to operate at the curve. However, studies of energy and environmental efficiency in production and households have for years repeatedly found that a very large fraction of society operates within the curve. Se, e.g., International Panel of Climate Change (1996), International Panel of Climate Change (2001), Jaffe and Stavins (1994), Porter and van der Linde (1995) challenged by Palmer, Oates et al. (1995). Very many firms and households simply use more energy, more raw materials, etc. than necessary to achieve the services and output they achieve. They can lower environmental pressure and cut down on expenditure at the same time. This is what is generally referred to as the *efficiency gap* or the *efficiency paradox*.

Why would firms and households use more energy than they have to? The debate has fostered explanations that explain why firms and households are so slow in adopting the best technologies and explanations that explain why some households and firms are reluctant to use them at all. Lack of information about alternative options is one of the obvious explanations of the former type whereas the continuing of practice of perverse subsidies and other incentives that makes it economically unattractive to energy consumers to go for efficiency represents another obvious explanation of the latter type.

Information and perverse incentives do also give rise to an eco-efficiency paradox paralleling the energy efficiency paradox. Market failures as well as government failures are often used to explain the paradox.

The implication for the standard model is that some of the abatement cost activities can be negative as shown in the figure below.



Environmental planning that disregards actual abatement costs and relies only on theoretical abatement costs is not very useful, but the theoretical abatement costs are important for establishing the boundaries of efficiency gains.

The standard model is static and the time dimension is therefore not present in the model. It is, however very important because the real economy is dynamic. When energy saving or environmentally benign technologies are developed, they are not applied everywhere immediately. The *diffusion process* into the economy is a very long stretched development – even when the new solutions are more economic as well. Because such physical changes simply take time, some efficiency gap is unavoidable. Thus, the factors explaining the efficiency gap are really explaining its magnitude, not its existence.

Abatement costs are also subject to *dynamic economies of scale*. New ways of abatement – like other new technologies - become less costly as the firms learn how to optimise their use and production. This means to some extent that the costs of abatement in the future depends on the amount of abatement in the present. Consequently, it is often misleading to assume the future abatement costs to be close to the observed abatement costs - the costs of the past.

Social Costs of Environmental Losses and the Damage Function

The function showing increasing marginal social costs with increasing pollution in figure 1 is actually a combination of two distinct functions: a physical damage function and an environmental value function represented in the following by equations (1) and (2) respectively.

(1) $Q = a + bZ + c^Z$

(2) $SC = -(e + fQ + g^Q)$

(3) $dSC/dZ = -d[e + fQ + g^Q]/dZ$

$= -fdQ/dZ - dg^Q/dZ$

Where

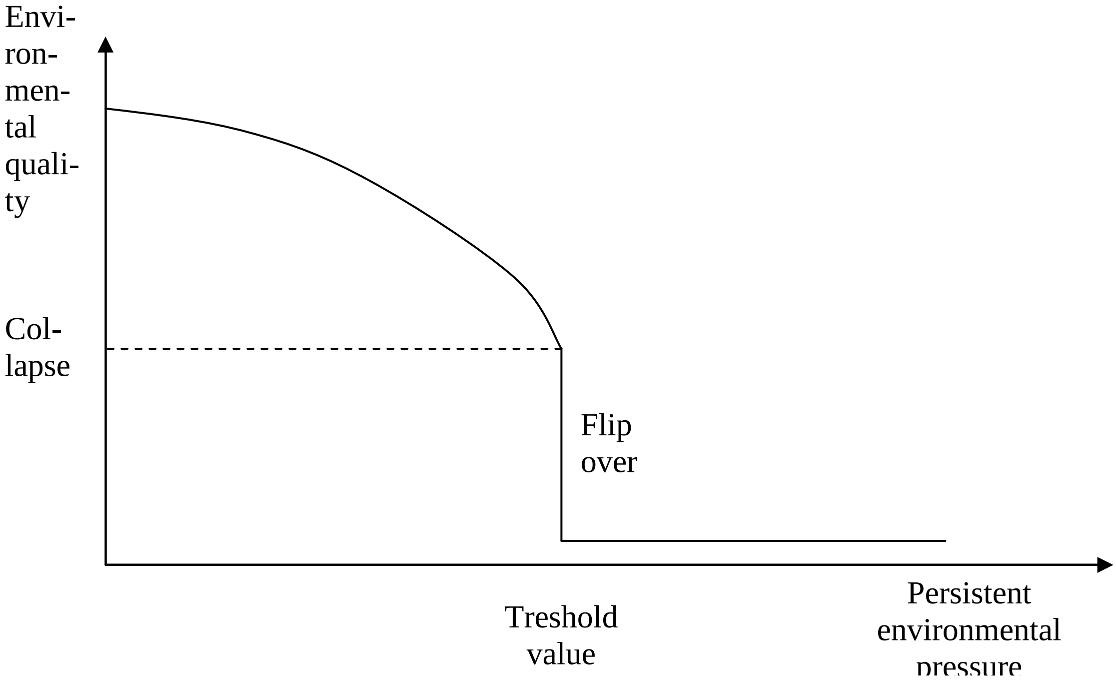
Q:	Index of environmental quality (higher Q is preferable to lower Q)
a:	Environmental quality independent of environmental pressure
Z:	Environmental pressure (e.g., emissions)
b :	Change in environmental quality as a linear function of environmental pressure
c:	Change in environmental quality as an isoelastic function of environmental pressure
SC:	Social costs of environmental pressure
e:	Value to society of an environmental quality independent of the level
f:	Changes in the value of env. quality as a linear function of env. pressure
g:	Change in the value of env. quality as an isoelastic function of env. pressure
dSC/dZ:	Marginal social costs of environmental pressure

Equation (1) is the physical damage function whereas equation (2) is the social value function. The level of sophistication varies much between practical analysts. The most sophisticated analysts search for patterns that can be described by linear functions as well as patterns that can be described by isoelastic functions. Few analysts even apply more complicated mathematical forms. The most primitive analyses rely on linear functions, i.e., c=g=0.

Scientists have difficulties with the physical damage function. In nature you will typically expect this kind of linearity only in rather narrow ranges delimited by discontinuities and qualitative shifts. The ecological balances that sustain a specific environmental quality, say, an ecosystem or a climate regime, are not indefinitely elastic. They are typically cumulating such that the ecosystem is resilient to a temporary high environmental pressure, but not to a persistently high or even increasing environmental pressure. Beyond a certain threshold value they flip over to an entirely different set of balances sustaining a fundamentally different ecosystem or regime. The assumption of a smooth continuous and twice differentiable damage function is only realistic within these limits and the threshold value has to be identified before it is possible to know whether the analysis is dealing with the realm of nature or the realm of dreams.

If we for the time being disregard the value function and concentrate on the damage function scientists would expect a relationship between the environmental pressure and the environmental quality like the one depicted in the figure below.

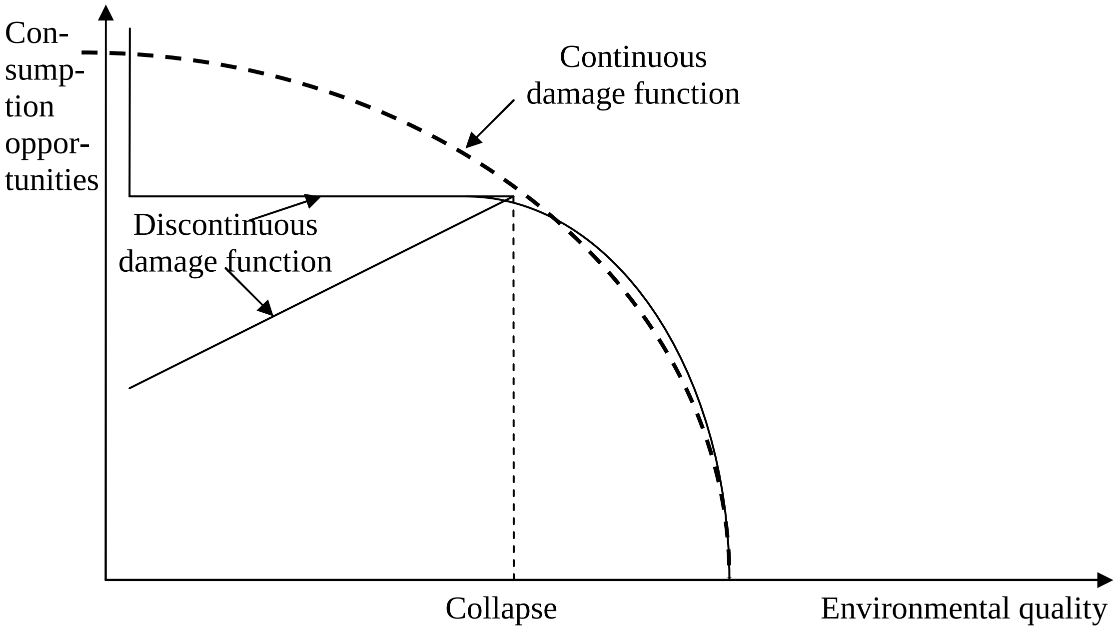
Figure 3. Physical Damage Function



This damage function can be described by an isoelastic function linking environmental quality to environmental pressure, but only up to the threshold value where a discountinuity appears. Moreover, in practical environmental planning, the notion of a constant environmental pressure is often too simplistic. This means that the damage caused by, say, emissions in year t depends not only on the emissions that have occurred earlier, but also on the emissions that are expected to occur after t.

The real options for choosing between consumption (or production) opportunities and environmental quality thus becomes more complicated when we use the assumption of a discontinuous rather than a continuous damage function. In the figure below we assume a linear value function and a linear marginal abatement cost (in the case equal to the marginal reduction cost) function.

Figure 4. Difference in the Trade-off between a Continuous and a Discontinuous Damage Function.



The importance for environmental planning of the standard assumption for the damage function is obvious. If the real choices between consumption opportunities and environmental quantity in the long run is delimited by the discontinuous function but the analysis assumes the continuous function, then it considers and potentially recommends choices that don't exist. Choosing a balance between consumption opportunities and environmental quality to the left of the collapse point is in fact abandoning the environmental quality in question all together and often irreversibly. The impact on aggregate consumption opportunities can also be significantly negative.

The Value of Changes in Environmental Quality

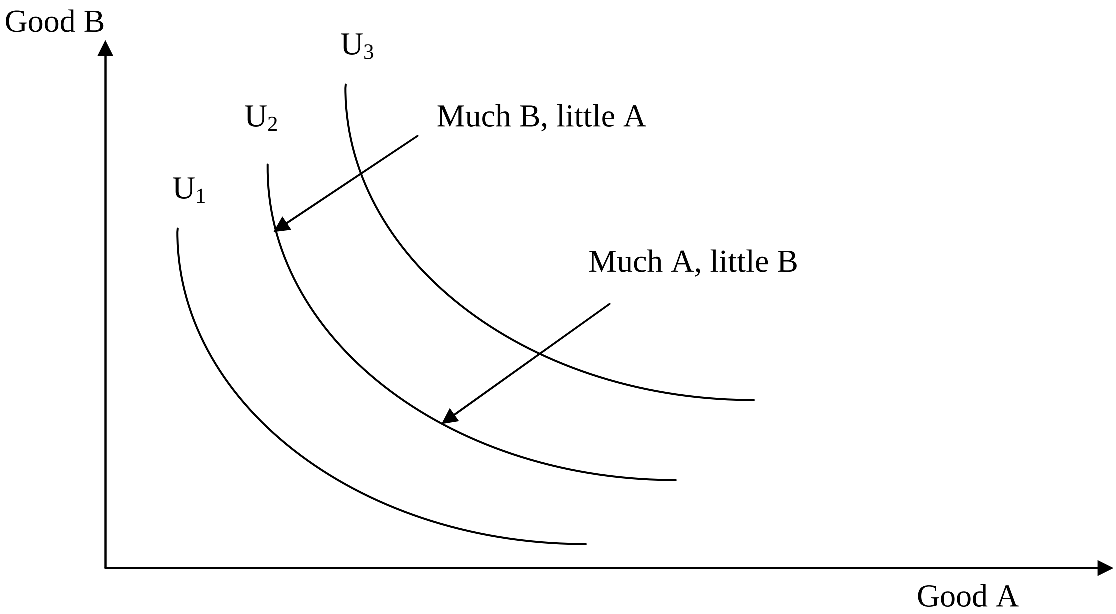
In mainstream economic thinking the consumption of produced goods is the ultimate purpose of economic activities and the purpose of consumption is human well-being. Environmental quality enters this hierarchy of uses through its importance for the ability of the economy to produce goods and through its direct importance for human well-being. From this perspective, the economic logic is that if the purpose of environmental quality is to sustain human well-being partly indirectly through a productive capacity, then what should be sustained is the level of human well-being and the productive capacity, not the environmental quality itself. Environmental quality is like any produced good only a means to enhance human well-being.

In economic analyses of changes in environmental quality in OECD countries the direct effects on human well-being are usually of higher economic value than the indirect effects via the productive capacity. In mainstream economics analysis of these values typically makes use of the standard method for analysis of market behaviour of customers. The value of a commodity is the customer's willingness to pay for the commodity. The analysis seeks to place such a willingness to pay for changes in environmental quality.

The result that you possible can get from such a methodological approach is subject to severe criticism. Sagoff (1998) has characterised it as a confusion of categories. We do not value environmental qualities as consumers but as citizens. Environmental qualities are not private goods for which persons have willingness to pay. The economic balance must be assessed for society as a whole, not on the base of narrow self-interest. Social values work different from willingness to pay and the preferences it reflects. Societal priorities are formed in the policy cycle and they are very much concerned with rights and minimum safe levels rather than gradual changes.

We can try to adapt the standard assumptions of consumer preferences to a framework of societal priorities more adequate for environmental-economic analysis. The figure below shows how two goods combined in different amounts can give the same utility level (e.g. U_2).

Figure 5. Preferences for Substitutable Goods

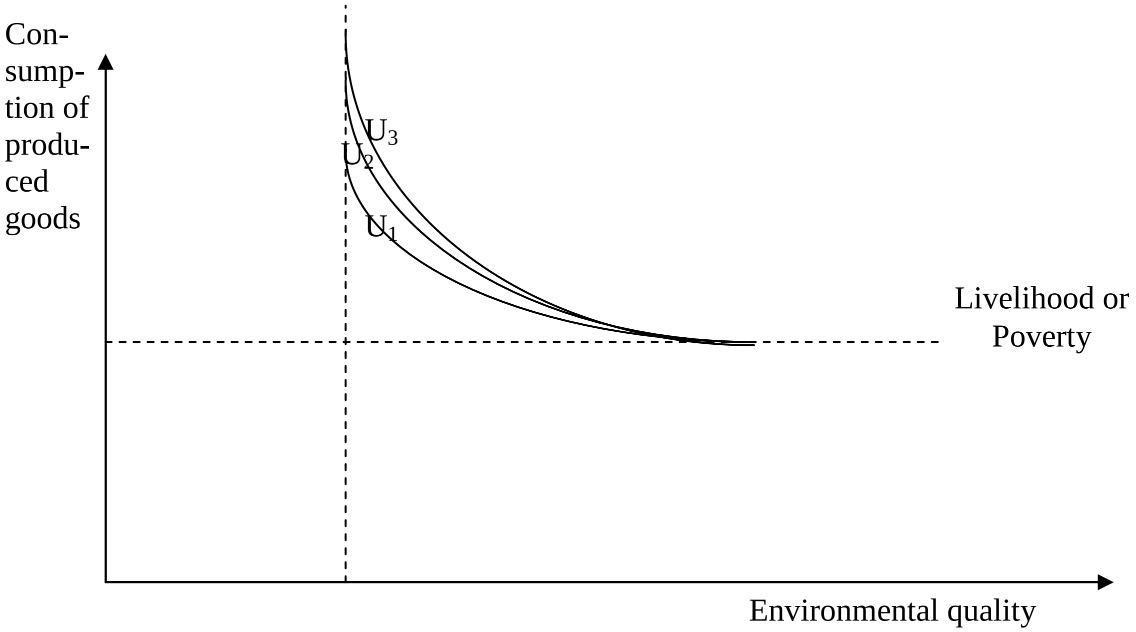


The consumer is as satisfied by getting ”Much B, little A” as y getting “Much A, little B”. All combinations at indifference curve U_2 are equally attractive. All combinations at U_3 are also equally attractive and the consumer will always prefer a combination on U_3 to one on U_2. She is assumed to choose the consumption bundle on the highest indifference curve possible given her budget and the prices.

It is often neglected in the standard model of the consumer that consumers choose within a space confined by lexicographic preferences. This is rarely a problem in analysis of markets for consumer goods but it is a big problem in analysis of environmental problems. This is because public policy or societal priorities usually are formulated in principles rather than prices. E.g., the policy principle that the European Central Bank is obliged to fight inflation, not, e.g., to reduce inflation by 1% if it can be done “cheaper” than at the cost of raising unemployment by ½%. Also environmental problems typically only become publicly acknowledged when the environmental quality is about to sink below the lexicographic limit. We often don't appreciate environmental goods – and other public goods – before we are about to lose them.

Rather than deriving the value of environmental quality changes using a model of the representative consumer, it can be derived using a model of the representative citizen. To the representative citizens political and moral principles are more important and this is reflected in the figure below by minimum- and maximum levels beyond which any combination of goods is unacceptable.

Figure 6. Environmental Quality and the Representative Citizen



The figure shows a preference map with lexicographic preferences, i.e., minimum levels below which any combination of goods are unacceptable. For the environmental quality dimension it could be, e.g., a quality level below which we get a high risk of death and illness or have irreversible losses of important species and ecosystems. In the consumption dimension it could be subsistence level or the livelihoods of co-citizens involved in activities degrading the environment.

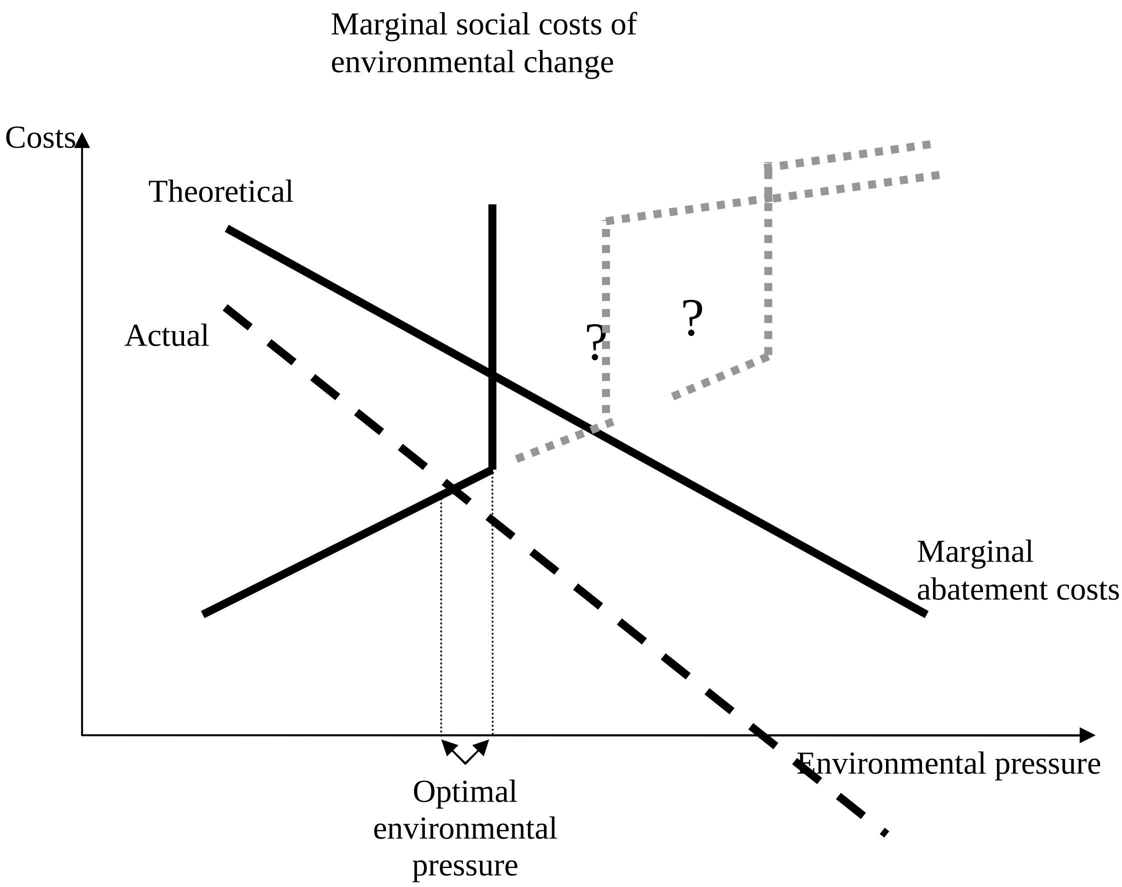
Lexicographic preferences reflect policy principles of what is unacceptable. E.g., loss of livelihood, consumption so low that we speak about hunger or malnutrition, inadequate health service, etc.

However, also in this aspect it is important to note that it is a static model reflecting a dynamic reality. The consequences of actions that change environmental pressure often appear a generation or two later. The rationality of undertaking the actions should therefore not be based on the preferences of the present but rather those of the future generations. We don't know a lot about them but if relative scarcities matter we should expect environmental qualities to be more valuable to future generations than they are to present. In this century the world population will grow by maybe 60-100%. The gross world product will grow by maybe 500-800%. The environment will not grow at all. Probably there will even be less of it.

A Standard Model with Inter-Disciplinarily Compatibility

The issues discussed above concern the acceptability of assumptions belonging to fields of other academic disciplines than economics. In particular science, political science, and ethics. In the figure below we comprise all the adaptations to the standard model in figure 1, that we have undertaken above.

Figure 7. Adaptations to the Standard Model



The figure shows a much more complicated picture of societal deliberation necessary to reach conclusions about environmental-economic problems. It is, however, a framework for economic analysis, which is compatible with standard assumptions in other academic disciplines and therefore much better suited for interdisciplinary analysis. The interdisciplinary character of sustainability analysis requires such a more compatible approach to investigation of the economic aspects.

Global responses to the climate change problem represent an environmental-economic problem where the economic analysis is much better suited with attempts for identify and quantify the components of figure 7 than those of figure 1.

The greenhouse effect has been known for almost two centuries and its link to CO_2 emissions from fossil fuel combustion in more than one century. The concentration of greenhouse gasses in the atmosphere and its impact on the global mean temperature is today fairly well documented. Some estimates of the physical damage that can occur to the right of the collapse point from a reduction in environmental quality (in this case Q would be measured as the pre-industrial global mean temperature minus the current global mean temperature) have been published although they constitute far from a complete account of the total damages. The threshold at which the system global climate system becomes unstable, global warming accelerates, and the climate system flips over to a qualitatively different state is, however, unknown. Models based on the scattered knowledge derived from climate studies in geological history suggests that collapse could occur when the global warming permanently exceeds 2° C above pre-industrial global mean temperature. The core long term objective for the European Union climate policy is to keep global warming "maximum global temperature increase of 2 °Celsius over pre-industrial levels and a CO_2 concentration below 550 ppm."…" In the longer term this is likely to require a global reduction in emissions of greenhouse gases by 70 % as compared to 1990." ((2002), art. 2;1). This is to prevent dangerous anthropogenic interference with the climate system. It will also increase the prospects for nature and societies to adapt to global warming and for vulnerable developing countries to develop their economies.

Societal priorities can be quantified based on opinion polls. They are, however, subject to temporary sentiments and fashion and the answers reported in them are largely un-reflexive. Group deliberation with interaction with experts and other more reflexive research processes have been developed in the recent years to get a better understanding of the informed social choice. Focus groups, which are similar play an important role in policy making at the top government level at least in some European countries. Scientific research in societal environmental-economic priorities could probably benefit much more from such studies and apart from economics they must draw on political science, sociology, law, and psychology.

The *threshold values* for environmental pressure reflect either culturally distinct perceptions of what is acceptable conditions of limits to ecological resilience or both. Ecological resilience is typically surrounded by scientific uncertainty and thus it is necessary to operate with a safety distance. Whereas the limits to resilience is a question that can only be addressed by science, the safety distance and culturally distinct perceptions of what is acceptable conditions are political, maybe based on some insights in social science. Thus, the important threshold values are not solely definable by hard science, but have important social science and political components too.

The threshold value is very convenient when the social cost of environmental pressure is not quantifiable within useful degrees of certainty as is often the case. When there is a threshold in the social cost function, the optimal environmental pressure will typically be at a point in a safety distance from this threshold. This means that we don't have to calculate highly uncertain estimates of external effects to find the optimal level of environmental pressure.

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