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***Weak and Strong Sustainability Indicators,
and Regional Environmental Resources***

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Abstract

Weak sustainability indicators often suffer from their unrealistic and inadequate assumption of substitutability between natural capital and man-made capital. Defining sustainable development in these terms is almost trivial although measurement problems as well as methodological and sociological issues may be considered as major flaws of operationalizing weak sustainability indicators. On the other hand, strong sustainability indicators rely on physical measures. This ecological economics approach concedes that the economy is embedded in matter and energy flows ultimately limited by solar energy input and the Earth's capability to produce renewable resources and cope with emissions of all kinds. Along the example of regional environmental resources like ground water in Austria, some thoughts on strong regional sustainability indicators are presented.

Congress topic: Environmental Management, Sustainability and Development

Keywords: Weak/Strong Sustainability Indicators; Regional Indicators for Sustainable Development

1 Introduction

Many attempts to operationalize the ecological concept of sustainability have been undertaken by the economics profession during recent years. It seems that many mainstream economists tend to focus their research on the assumption of substitutability between man-made (manufactured) capital and natural capital (natural resources, goods and services). The crucial points of this discussion can be seen especially in contributions by Solow (1993) on a more theoretical level and by Pearce and Atkinson (1993) on an empirical level who all plead for at least partial substitutability. As Daly (1992) has pointed out, the assumption of substitutability cannot be drawn in the search for an adequate treatment of natural resources in economic and ecological modeling and policy.

The paper tries to clarify some questions regarding weak and strong sustainability indicators as well as sustainability rules for dealing with regional natural resources.

In the first part of the paper, the assumption of substitutability is discussed in various aspects. Given weak sustainability indicators, calculating the „sustainability“ of a regional system (or national economy) becomes almost trivial. If the rate of depreciation of natural capital is at least offset by savings (accumulation) of man-made capital then the economy is on a sustainable development path. Besides the missing of the social „branch“ of sustainability, the depreciation-savings approach lacks understanding of the fundamental objections against monetizing natural resources (e. g. biodiversity). Some crucial aspects in this context are discussed in the paper (e. g. lexicographic preferences, „consumer“-vs.-„citizen“ approach).

The strong sustainability indicators are in favor of different approaches, e. g. the save-minimum-approach. The second part of the paper deals with practical sustainability rules on a regional level regarding water resources. If sustainability as a concept for future ecological, economic and social development is taken seriously, only physical constraints (taking time as an additional factor of production into account) and an applied precautionary principle can indeed lead to sustainability.

2 Substitutability and Sustainability

On the basis of several attempts to operationalize the framework as well as the indicators for a sustainable development (see e. g. WCED, 1987; Daly, 1992; Weterings and Opschoor, 1992; Schmidt-Bleek, 1994; Wuppertal-Institut für Umwelt, Klima und Enerige, 1995; Kosz, 1994) the environmental and ecological economics branch is working on models to define the significance and the crucial elements of an economic development which meets sustainability criteria. Starting point of this discussion is the notation of the „Total Economic Value“ (TEV) which primarily sets the scene. The TEV should in principle comprise all relevant economic values of a natural resource. The size of the TEV depends not only on the decision which values (or preferences) are to be counted as such, but also on the choice of the relevant discount rate. The economic value of an asset (e. g. a machine, a stock of natural assets) is conventionally calculated by all goods and service which can be produced (or maintained) by the asset now and the future. While with man-made capital, this way of calculating the economic value may be an appropriate way of dealing with economic trade-offs and internal interest rates of investments, informational problems with natural assets can hardly be overcome. The choice of discount rate is a scientific and empirical problem known for long: Should a rate of time preference which might be very small due to ethical considerations regarding future generations be applied, when an individual discount rate given consumer goods or interest rates of alternative investments are probably much higher? However, the TEV is - in theory - divided between two crucial components (Pearce and Turner, 1990):

$$TEV = UV + NUV \quad (1)$$

Equation (1) subdivides the Total Economic Value (TEV) into two elements which are both difficult to define and to measure. The use value (UV) of a natural resource is defined as the economic value of the resource derived by goods and services produced or directly consumed. The use value in this sense can be calculated by empirically testing the importance of the natural resource in the production function of firms as well as in the utility function of private households. A production function of a firm thus can be enlarged by an argument explaining natural resources inputs (e. g. $Q = f(L, C, R)$, where the output of the firm depends not only on the input of the „classical“ factors of production (labor, capital); additionally natural re-

sources (R) are included. The concept of use values of natural resources (UV) is not limited to direct economic benefits such as raw materials, consumption goods and scientific benefits. Preferences for the protection of the resource because of their economic function as fundamentals for recreation and sports are included as well.

Usually cash values for productive and consumptive functions as well as preferences for recreation are derived by means of indirect valuation methods such as the production function approach, hedonic pricing and travel cost analysis. The basic assumption in all these approaches is that the demand for a complementary good (e. g. value added in the pharmaceutical industry, demand for apartments, number of visits to a recreation area) is directly correlated to environmental indicators like availability and quality of resources for industrial production, immissions in a certain neighborhood as well as beauty of and biodiversity in the recreation area.

The second even more important element of the TEV is the nonuse value (NUV) of a natural resource comprising all values which are derived besides the direct (anthropocentric) use of a resource. Typically the protection of species is considered mainly as a nonuse value due to aesthetic or ethical values. NUVs can be divided into the well-known components of existence, option, and bequest values. While option and bequest values can be seen as premiums assuring the future existence of the resource for one's own future use or as a heritage to one's children, the existence value is given by preferences for protection of natural resources merely because they exist (based e. g. on altruist or paternalist motives). Nonuse preferences are valued mostly by direct measurement methods such as the contingent valuation method (CVM) founded on welfare economics. Monetary measures for nonuse values include compensating and equivalent compensation, operationalized by means of willingness-to-pay (WTP) or willingness-to-accept (WTA) bids in a hypothetical contingent market. As there are no markets on which nonuse characteristics of natural resources are traded, the „complementary“ good of these values is the consumer's sacrifice she feels in her wallet when purchasing a satisfying quality level of the natural resource. This directly connects to the problems of substitutability and methodological measurement problems discussed in detail below: Besides informational restrictions, fundamental uncertainties as well as problems of democratic public choice, this

approach directly assumes the willingness to exchange natural goods for money which cannot be seen as *á priori* given.

Especially neoclassical environmental economics focuses on the so-called weak sustainability rule assuming total substitutability between natural capital and man-made capital. The weak sustainability rule has its roots in capital theory (Victor, 1991). The idea behind is that mankind has a certain total capital stock at her disposal. This capital stock consists of two components:

$$K = K_N + K_M \quad (2)$$

The total capital stock K is set up by K_N (natural capital) and K_M (man-made capital, manufactured capital). The first part (natural capital) is measured by the TEV discussed above. Man-made capital consists of all physical (machinery, infrastructure) and nonphysical (human capital) parts of the anthroposphere. An at least constant (non-decreasing) capital stock K is the indicator for a sustainable development. This weak sustainability rule presupposes that natural capital and man-made capital can be traded off against one another. As long as the „worth“ of the capital regardless of its composition is non-decreasing over time, sustainability is achieved. Interestingly, the empirical studies in this field mainly take the present capital stock as given, only considering that these entire capital stocks remain at least constant. There is nearly no consideration whether the actual capital stock may be too low to maintain (sustain) economic development in the future. Furthermore, assuming that a species only has one marketable service to offer, there would not be a reason to protect that species if this particular service can be provided by other (artificial) means.

Equation (2) is an expression of the view that natural goods and services can in principle be supplied by man-made capital, that means that natural benefits can be artificially produced. Even if the natural capital depreciates, there is no danger for sustainability if at the same time man-made capital is being produced to compensate for these losses. The substitutability assumption according to this capital theory approach is a strictly anthropocentric one, and it is „optimistic“ insofar that even if the technological standard today does not allow a perfect substitution between natural and man-made capital, with increasing scarcity of natural resources

approaching depletion, and higher prices, innovations will take place to compensate for these losses. This viewpoint is also partly incorporated in Daly's second sustainability criteria which says that non-renewable resources are allowed to be depleted when new technologies are financed to substitute these resources at the same time. Financing should take place by levying a sort of scarcity fee (Daly, 1992).

The depreciation of natural capital in general can, as already mentioned, be compensated by an increase in man-made capital. It is not necessary to calculate the total economic value (TEV) respectively the total capital (K) to conclude whether an economy is on a sustainable development path. The only thing which has to be known is a measure for the depreciation of capital as well as the savings per period (usually one year). This leads to a measurement of sustainability by the „savings rule“ which is an expression for the „marginal sustainability“ of an economy. If the parameter Z is positive, the economy tends to a higher degree of sustainability:

$$Z > 0 \text{ if } S > (N + M) \quad (3)$$

where N denotes the periodical depreciation (exploitation) of natural capital, while M is the depreciation of man-made capital. S denotes all savings of the economy (both in natural and man-made capital). If total savings are higher than total depreciation, the economy is on a sustainable development path because there are net savings which increase the total capital stock. In this sense, abstracting from the rather difficult problems of measuring the depreciation of natural capital, calculating Z in equation (3) becomes almost trivial. Pearce and Atkinson (1993) have adopted this simple conclusion for their work on a group of economies. Compensated for the different income levels, they found that those industrial countries (USA, Japan, Germany) consuming relatively as well as absolutely the highest level of resources (energy, raw materials etc.) are those facing a sustainable future while poor countries like Indonesia,

Nigeria or Madagascar are consuming more of their capital than they add as savings to their capital.¹

This rather astonishing result shows on one hand that weak sustainability indicators like the savings rule according to (3) incorporate significant measurement problems, and on the other hand, that such an indicator seems to be not very helpful in discussing which economy is on a sustainable development path. Besides the fact that the substitutability assumption is at least doubtful, there are a number of problems associated with the monetary valuation of natural capital which is needed to compare natural capital and man-made assets. Section 3 concentrates on some crucial elements of monetary valuation of natural capital.

3 Environmental Valuation and Substitutability

3.1 Lexicographic Preferences

As mentioned above, the savings rule approach discussed in section 2 is an anthropocentric one aiming at deriving the „worth“ of an asset, be it natural or man-made, by valuing the functions provided by this asset (valuation of assets in the „cash economy“ according to Price, 1993). Even if it is assumed that all functions can be valued from this viewpoint, e. g. by asking people for their willingness-to-pay for the protection of species because they hold altruistic motives or feel moral satisfaction, the method of monetary valuation presupposes that people are prepared to trade natural goods for money. It is this trade-off people are willing to accept. But this approach leaves out preferences which cannot be stated by respondents in a monetary form. This is especially the case when respondents either are not able to make adequate deliberations on the subject, or when respondents refuse to value natural goods in monetary terms. Refusing to answer a valuation question can be explained by respondents` point of

¹ Pearce and Atkinson have been heavily criticized for their work and conclusions on several grounds (see e. g. Gowdy and O`Hara, 1997). In this context, Endres and Radke (1998) discuss the combination of weak and strong sustainability indicators and conclude that there are some natural assets which can be substituted by man-made capital while others are not substitutable.

view that there are moral (ethical) obligations which principally cannot be valued because there is only „right“ or „wrong“. In this case, some economist have spoken about lexicographic preferences (Hanley et. al., 1994; Spash and Hanley, 1995): These are preferences where a trade-off between the good for which these preferences are held and other goods is denied on (probably) ethical grounds. When natural goods are concerned, many respondents (up to one quarter) hold preferences of that kind. This can be a serious flaw for the valuation approach which is founded on neoclassical theory.

Sustainability in its „weak“ form is based on this willingness to exchange. Therefore, preferences in a lexicographic form, where there might be only one „right“ or „wrong“ development decision, which can be the case with biodiversity or landscape protection, do not fit into the model of substitutability of natural capital and man-made capital (money).

3.2 Consumer vs. Citizen

An additional argument against „weak“ sustainability indicators may be seen in the divergence of socio-economic roles of economic agents as „consumers“ and „citizens“. There is a lively debate in ecological economics and surrounding fields (e. g. institutional economics) to what extent the individual choice may differ, depending on the „viewpoint“ or „role“. Sagoff (1988) started this discussion with stating that individuals are not only consumers acting according to their personal sacrifice when valuing natural goods. The monetary valuation operationalizing the „weak“ sustainability approach is based on an individual utility function where the willingness to pay depends on the different „utility“ levels obtained as consumer. Contrary, especially when dealing with public goods, economic agents do not only maximize their individual utility but act as citizens concerned for the better of society.

Taking this divergence of roles into account, it becomes clear that a weak sustainability rule, based on market prices and consumer choices lacks the preferences of economic agents which they hold as citizens. With the „weak“ criteria some preferences may not be included, and measuring only market values instead of values held by the „civil society“ may pose serious

dangers to a sustainable development. The latter values may only be captured by „strong sustainability“ criteria especially due to their incommensurability.

3.3 Time, Information and the Precautionary Principle

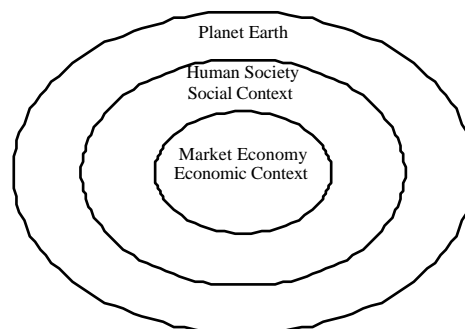
A final point before discussing in more detail sustainability for a regional natural resources should be made regarding the informational constraints facing individual perceptions of natural values and future events. Theory concedes that - ultimately - in every market decision risk and uncertainty is captured because fully informed agents incorporated the future in today's behavior. There are many problems with this assumption, e. g. it cannot be presupposed that economic agents value future events by an adequate discount rate. „Adequate“ in this context means that there should be made a distinction between discount rates for trading off present versus future consumption and valuing the welfare of future generations. Furthermore, these discount rates may significantly differ from the rates at which ecological systems regenerate, not to speak of geological time scales.

Strong sustainability indicators, only directly based on individual perceptions of future events, try to focus on longer time scales than weak indicators. Besides this time scale problem, informational constraints of individuals as well as risk neutral or risk loving individual behavior contrary to risk averse social behavior should lead to more stringent strong sustainability frameworks. As Gowdy and Olson (1994) making the connection between individual valuations and the knowledge science has accumulated have put it: „Contingent valuations, even in theory, are no better than the information available to the most knowledgeable people. Knowledge of the intricacies of the rain forest environment [...] is almost nonexistent even among biologists specializing in that area“ (p. 169). And concluding: „What sense does it make to set environmental policy on the basis of opinion surveys of an uninformed public?“ (p. 170). It cannot be assumed that economic agents in their individual market environment behave as if they follow the precautionary principle of environmental policy.

4 Strong Sustainability Indicators for Regional Water Resources in Austria

On the basis of the discussion of the weak sustainability rule and its foundations, the ground for approaching the concept of a strong sustainability rule is prepared. To sum up, the main problems of the weak sustainability rule are the missing substitutability between natural and man-made capital, and major flaws of the individualistic monetary valuation of natural goods in general. It can be concluded that the weak sustainability rule has in principle a different world view regarding the „embeddedness“ of the economy in a social and ecological context. While standard environmental economics assumes economy to be a black box where inputs and outputs are measurable and no physical limits to growth exist, ecological economics deals with the physical limits (especially thermodynamics) and the dynamic development of ecological systems. A simple but obvious graphic has recently been drawn by Gowdy and O'Hara (1997) showing the context in which economic activities take place (Figure 1).

Figure 1: Hierarchies of sustainability



Source: Gowdy and O'Hara, 1997, p. 241.

Because the economy is only a part of the „whole system“, the physical limits of sustainability are obvious. Besides problems with valuing natural goods in the „cash economy“ (lexicographic preferences, uncertainties, missing information) it is this embeddedness which brings the most significant problem with the weak sustainability criteria. Thus, a number of strong sustainability criteria have been developed (e. g. save-minimum standards, the precautionary principle for environmental policies).

The discussion of strong operational criteria of a sustainable development has gained much importance since the publication of the „Brundtland-report“ in 1987 (WCED, 1987). Since then, many concrete (and not so concrete) modeling, data collection and discussion have been led, conferences have been attended, and the public interest has increased to a large extent. Nevertheless, many discussions in the fields of sustainability are very abstract, do not include implementation efforts and lack (sometimes in a curious way) practical steps towards sustainability.

Concentrating on one of the most important natural goods, the use of water resources within a sustainable economic is seen by many authors as a crucial element of a sustainable development. Being a very rich country regarding water resources Austria has tried to protect the quantity and quality of water resources by one of the most stringent legal frameworks („Wasserrechtsgesetz“, 1959). Nevertheless there are regions in Austria where the sustainability criteria are injured by the amount of water extracted from the ground resp. where agricultural production and (industrial) waste sites cause serious damages to the quality of the ground water (see for a short discussion of the legal framework and of regional water resources in Austria section 5 below). Water in a sustainability context can be regarded as a regional (national) resource. The target of a sustainable water resource management is to achieve a balance between the extraction and the regenerating capacity of water resources. The leading principles could be summed up in the following way (see Hüttler and Payer, 1994; Kosz and Bröthaler, 1996):

- (1) Within a naturally given catchment area the yearly extraction should not exceed the yearly renewal rate of the water resource.
- (2) The organic and anorganic load into the water resource should not exceed the regeneration capacity (carrying capacity).
- (3) The seasonal differences between water supply and demand should be taken into account.
- (4) Imports or exports from one region to another are only sustainable if principles (1) to (3) are fulfilled.

Each Austrian citizen uses 150 l/d (communal water supply) while industry, agriculture and thermal power stations use additional 1.350 l/d.c.² It cannot be said whether the environmental space of each Austrian for using water resources is injured by the actual use of totally 1.500 l/d.c (for all numbers see Hüttler and Payer, 1994). However, these numbers show that not only the use of water resources and industries have to be taken into account, but every use of water resources (e. g. as cooling medium in power stations, carrier of kinetic energy used in hydro-electric power plants) has to be considered from a sustainability viewpoint. If we sum up all materials and energy used in the Austrian economy („material throughput“) around 80 % of all material flows through the Austrian economy is water (measured in tons). As the sustainability criteria show defining the environmental space for water resources cannot easily be done: the regional situations within Austria must be taken into account (e. g. water extraction in the „Marchfeld“, an area with few rain but intensive groundwater uses, might be not sustainable while extracting the same amount of water near the Danube river would be sustainable; see above on some more concrete numbers).

The development of water saving strategies especially in cities have their origin in the regional characteristics of the quantity and quality of the regionally existing and usable water resources. The most sophisticated water saving strategies have been consequently adopted by those cities whose water resources are scarce (e. g. many major German cities like Hamburg, Frankfurt or Berlin depending on ground water for drinking purposes are good examples for feasible and effective water saving strategies).

5 Case Study: Legal Approach and Regional Problems Towards Sustainability

Some of the above mentioned sustainability criteria for the use of water resources are legally set to force by the Austrian federal law on water resources („Wasserrechtsgesetz“, 1959). Interestingly, although Austria is that rich of water resources, it has one of the most stringent water pollution acts in Europe. One basic legal rule is that every use of water, be it the extraction of groundwater or the discharge of sewage, has to be limited according to the state of the

² „l/d.c“ denotes the consumption of water (in liters) per day (d) and per capita (c).

art in control technologies to minimize eventually harmful uses³. Groundwater has to be protected in its natural state, and the polluter-pays-principle as well as the avoidance principle are the leading objectives. In the latest report of the Ministry of Agriculture and Forestry (which is responsible for administrating the legal frameworks regarding water resources), the term sustainability explicitly becomes part of the „official“ language. The Austrian Water Act especially regarding the discharge of sewage is based on two approaches, which are part of some of the strong (physical) sustainability criteria discussed above in section 4:

- *Principle of minimizing emissions*: This principle states that emissions have to be minimized using the state of the art of control technologies. For over 60 economic branches as well as communal sewage treatment, technologies and standards are set to control emissions.
- *Principle of considering the regenerating capacity*: Emissions have to be controlled to the extent that immissions standards regarding the quality and regenerating capacity are met.

Emissions standards do not secure that immission standards are met everywhere. In every single case the more tight standard has to be applied, either restricting emissions to the state of technology if immissions standards are met, or forbidding the use of the water resources if immissions standards are not met even with the most stringent application of state-of-the-art technologies.

Despite these impressive efforts⁴ to protect water resources there are some regions within Austria where the consumption of water exceeds the regeneration rates significantly. On average, only 3 percent of total water supply are currently used; taking groundwater supply as basis, only 6 percent are extracted. The most fertile soils lie above others in the Eastern part of Austria, namely in the „Marchfeld“, the „Waldviertel“ and „Weinviertel“. The first and third face serious problems because of high extraction rates of groundwater extraction which lie

³ See for this and the following „Wasserrechtsgesetz 1959“ and Bundesministerium für Land- und Forstwirtschaft (1996).

⁴ Compared to actually discussed frameworks of the European Union, the Austrian water regulations are more stringent with both principles.

above the regenerating capacity as well as above the yearly precipitation. This leads finally to an additional problem of weak sustainability indicators: While strong indicators can easily be adjusted for regional environmental resources (e. g. by setting immission or extraction standards), the weak indicators cannot be differentiated according to the regional situations.

6 Summary and Conclusions

The discussion of weak and strong sustainability is sometimes seen as a discussion between (neo-classical) environmental economics and ecological economics. While the former branch of economics assumes substitutability between natural and man-made capital, and optimism towards future technologies developing out of increased prices for environmental inputs, ecological economics usually prefers physical („strong“) sustainability indicators, given that substitutability and individual (market) valuations of natural goods face serious problems because of the „nature of the good“ (e. g. informational constraints).

Interestingly, the Austrian Water Act especially distrusts a pure (environmental) economics approach towards protection of water resources which can clearly be seen as regional resources. Especially when it comes to regional resources, a weak sustainability indicator cannot be applied.

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