Economic sustainability of the economy: concepts and indicators

Joachim H. Spangenberg

Sustainable Europe Research Institute Bad Oeynhausen,
Hugo Distler Str. 1b, D32549 Bad Oeynhausen, Germany
Fax: +5731 9819496 E-mail: joachim.spangenberg@seri.de

Abstract: Every society can be described as comprising four dimensions, the economic, social, environmental and institutional. Each of them is a complex, dynamic, self-organising and evolving entity in its own right, making the coupled system one of tremendous complexity. For this system to be sustainable, each of the four subsystems has to maintain its capability to survive and evolve, while the interlinkages of the subsystems must enable a permanent co-evolution. Finding the appropriate level of complexity for descriptions and models is a necessary precondition for adequate analysis and to avoid wrong prognoses. As this level of complexity is beyond the analytical capacities of current economic theories, a system analysis perspective is presented as a framework for discussing the co-evolution of economy, society, and nature. In this context, the economic, social, environmental and institutional sustainability of the economy can be defined and economic theories can be assessed regarding their usefulness for the description of a complex evolving system, like the economy. Unfortunately, there are few applications of the rather abstract system analysis of complex evolving systems to the economy so far. Consequently, before using it for assessing the sustainability of economic development processes, sustainability must be defined for such systems. This is the *raison d'être* of Orientor Theory, providing the means to assess the sustainability of the economic system, albeit still on a rather abstract level. Based on systems and Orientor theory, the paper derives suggestions for criteria of the sustainability of the economy, and in particular its economic sustainability.

Keywords: economic sustainability; systems analysis; sustainability criteria; Orientor theory.

Reference to this paper should be made as follows: Spangenberg, J.H. (2005) 'Economic sustainability of the economy: concepts and indicators', *Int. J. Sustainable Development*, Vol. 8, Nos. 1/2, pp.47–64.

Biographical notes: Joachim H. Spangenberg, born 1955, is Vice President of the Sustainable Europe Research Institute SERI, Vienna, and Professor Invite at the C3ED, Université de Versailles St.-Quentin-en-Yvelines. He studied Biology, Mathematics and Ecology and holds a PhD in Macroeconomics. Before joining SERI he worked at the Wuppertal Institute and the Institute for European Environmental Policy.

1 The economic discourse: disputing strong comparability and commensurability

In the economic debate, sustainable development is most often described as the need to maintain a permanent income for humankind, generated from non-declining capital stocks (Hicksian income). Thus, in this perception at least, constant stocks of human, man-made, natural and social capital (Serageldin, 1997; Pearce, 1997; Serageldin and Steer, 1996) are considered as necessary and often sufficient criteria of sustainable development (Pearce et al., 1990; Pearce and Atkinson, 1993; Pearce and Barbier, 2000).

1.1 Terms and explanations

A controversy shaping much of the economic debate has arisen about the question whether each capital stock has to be maintained independently (strong sustainability, Daly, 1991), or whether the sum of all four capital stocks has to be non-declining (weak sustainability, Pearce and Turner, 1991). Although focussed on sustainability, this dispute brings to light, the fundamental discrepancies between its participants and some of their common ground. In particular, both positions are based on the assumption of strong comparability, the existence of a single comparative term like 'utility' by which all different actions can be ranked (this definition and the following ones are based on O'Neill (1993).

On this shared basis, the *weak vs. strong sustainability dispute* is the result of diverging assumptions regarding strong or weak commensurability. Strong commensurability refers to the existence of a common unit of measurement of the different consequences of an action based on an ordinal scale, like monetary value, whereas weak commensurability implies a common measure based on an ordinal scale of measurement. Strong commensurability is an implicit key assumption of neoclassical economics, and the indispensable basis for its concept of economic rationality (Martinez-Alier et al., 1998). It implies substitutability and thus weak sustainability, whereas strong sustainability is based on a concept of weak commensurability.

This dispute structure results in the misguided perception that there is only one possible choice, the one between weak and strong sustainability, resulting from strong and weak commensurability, respectively, with strong comparability assumed as a given fact. Such a narrow view constitutes not only an academic problem, but has significant implications for the policy recommendations and strategies based on it. So, for instance, as global warming resulting in climate change is to go on for some centuries and sea levels rise for some millennia, even if human impact was phased out now, Tol (2003) argues, it is too late for strong sustainability anyway. Consequently, only weak sustainability remains as an option, and thus strategies must be based on substitution and compensation (assuming strong commensurability) rather than on reducing greenhouse gas emissions.

Opposed to this, weak comparability refers to an understanding according to which, in decision situations irreducible value conflicts are unavoidable but compatible with rational choice, employing practical judgement. Weak comparability rules out strong commensurability; the decision for weak comparability as a basic concept is one of the crucial differences between neoclassical and ecological economics. From the choice of a world view incorporating weak or strong comparability, rather different concepts of economics emerge, a dispute that can be traced back at least until the early 20th century (Martinez-Alier et al., 1998).

In the macro-economic debate, few other economic sustainability criteria are mentioned, like innovativeness (Rennings, 2000), competitiveness (Klemmer et al., 1998) or public debt (Bundeskanzleramt, 2002); while criteria like inflation or trade imbalances are politically prominent, but hardly ever located in a sustainability context with its broader perspective and the need to balance different interests. Again, other, partly more traditional criteria like aggregate demand, consumption levels and savings rates play a minor role in the current debate (Etxezarreta et al., 2003). So whereas there are ideas to be found in the economics literature regarding the environmental, social and sometimes also the institutional sustainability of the economic system, there is hardly any information available on the *economic sustainability of the economy* (and thus not on the overall sustainability of the economy, which comprises all four components). Even less so, criteria of economic sustainability have been developed for the other dimensions. This is all the more surprising, as the economic sustainability of social security systems or environmental protection legislation is a prominent issue of the policy debate.

1.2 Application to economics

As of today, all mainstream policy debates on sustainable economic development tend to focus on increasing the stock of man-made capital and the degree to which other capital stocks may be reduced on this account (OECD, 2001). They refer to this fact as substitution although the opposite is never discussed (substitution is reversible), and they are dependent on the existence of both strong comparability and commensurability as a basic assumption of the neoclassical paradigm (Spangenberg, 2005). Mathematically, the unlimited substitution possibility is expressed in the production functions (Cobb-Douglas and others) which, even when including resources, imply unlimited substitution possibilities and thus violate the first law of thermodynamics, mass balance (Daly, 1997).

In other words, continuous and indefinitely (or at least long-term) sustained growth is – often implicitly – assumed to be a part of the concept of sustainable development of the economy by most authors. Growth is perceived as a sufficient condition for all kinds of social improvements, although this is to some degree contra factual: while empirically, employment is correlated to economic growth, distributional justice is not (Alber, 2002). Decreasing inequality with increasing prosperity (the 'Kuznets curve') does not emerge automatically, but results from active social, i.e., redistribution politics in affluent countries (Kuznets, 1955). Nonetheless, under the standard assumptions, additional criteria regarding which kind of growth might be sustainable (see e.g., Spangenberg et al., 2002) are not discussed, and rate of growth is considered the only relevant parameter. Specific qualities do not exist, as each quality can be expressed as a quantity by the same numeraire, which in economics is usually money. Expressing quantities of different factors in units of the same numeraire reflects the assumption that the factors are substitutes (Daly, 1997). However, this substitution between different capital stocks is only plausible as far as it refers to the function of these capitals as production factors. If, under changing factor constellations, the product is equivalent in terms of the common numeraire, substitution is considered possible. Based on the assumption of strong comparability, this analysis refers only to one criterion, utility production, and completely neglects all other aspects of the economic sphere and the unavoidable interaction of all four capital stocks (i.e., the trade offs that occur with other functions of the respective capital stocks). According to the second assumption, strong commensurability and utility generation can be sufficiently described by monetary measurement.[1]

> Describing the sustainability-relevant aspects of a simple economic process illustrates the limits to understanding the impacts in all four dimensions imposed by this approach: If a new machine (man-made capital) replaces skilled workers, this may be an effective substitution regarding production and value creation, but in terms of resource consumption (environmental capital), income generation (social capital) and skills training (human capital), the outcome is definitively different, a fact which is not captured as long as all impacts are reduced to their function in the production process, and measured according to the assumption of strong comparability.

If asking for the impact on the respective system or capital stock beyond its economic component,[2] for instance for the number of unemployed, not for the costs of unemployment, or for the level and impacts of climate change beyond the costs incurred, real substitution is hardly imaginable. Given this, it is all the more heroic that economists still dare to make prognoses for the future development of a reality with which they are so much out of touch. In total, the weakness of the strong commensurability paradigm, postulating the validity of the economic logic and numeraire outside the economic system, is obvious and has been broadly discussed (for instance in Ecological Economics, 1998).

But it is not only the assumption of strong commensurability which causes problems; they already begin when assuming strong comparability (combined with strong or weak commensurability). The assumption implies that all systems, regardless of having a common denominator or numeraire, at least have some common key characteristics which would permit comparisons on the basis of an ordinal scale ranking. If used as a basis for comparing systems, these traits can refer to one externally defined purpose like utility for the human society or its individuals. In this case they are specific to the respective objective, but have no meaning for the sustainability of the system as such. Or they are intended to be sustainability criteria – this would imply that the same characteristic is decisive for the sustainability of all four dimensions. However, as far as we know there is no common factor, decisive for social cohesion, human satisfaction and the integrity of ecosystems. These criteria, at least as crucial to sustainable development as monetary value, have to be monitored with their own yardsticks, and must be measured with their specific numeraires. An economic theory insisting on strong comparability remains helpless when trying to understand economically relevant environmental and social processes.

From this extended perspective the question of substitution between two of the capital stocks simply makes no sense; it needs to be replaced by a systematic or intuitive multi-criteria approach referring to all four dimensions, their characteristics and interactions, in order to permit their assessment in a true sustainability perspective. Then the appropriate question would be whether the balance of impacts of a certain action on all four capital stocks is considered positive, negative or neutral, according to an explicit set of multi-dimensional criteria (still this assessment will vary between individuals and over time). Consequently, ecological economists argue that the stocks are complementary rather than substitutes and that growth of one stock at the expense of others can be counterproductive ('uneconomic growth', Daly, 2001). From this point of view, in a world of weak comparability, the quality of growth is decisive.

These problems are specific to orthodox economic thinking; they play no significant role in ecology, sociology and political sciences (which do not assume strong comparability as there is simply no functional equivalent for water, communication or decision making in these disciplines; see e.g., Ehrlich et al., 1999). Thus they seem to be more characteristic for the challenge that sustainability poses to economics than the economic challenges of sustainable development. An economic theory capable of dealing with the sustainability challenge must be based on weak comparability and incommensurability, and it must overcome logical misperceptions, resulting from a rather static instead of a dynamic understanding of the systems (Coleman, 1990).

The restriction of economic thinking to strong comparability and commensurability (the monetary perspective) imposes a serious limitation on the analytical capacity of the discipline in the field of sustainable development analysis. As a result, for instance, labour economics ignores the majority of working hours as they are unpaid (thus creating a systemic bias against sustainable development strategies, see Spangenberg, 2002), and consumption theory has no understanding of consumer satisfaction, unless the need for goods and services in the process to generate it, is expressed in the market.[3] Nonetheless the capital stock approach provides a number of relevant insights. This is clearly indicated by the calculations of total wealth performed by Serageldin (1997): If development processes are increasing the man-made capital stock by depleting human, natural and/or social capital, economic development can happen to be de facto decreasing the wealth of nations, even in the sense of the weakest theories of sustainable development permitting unlimited substitution of capitals. Unfortunately, this negative development can go undetected for a long time, as long as the indicators used for measuring wealth (GDP, trade balances, etc.) only take the man-made capital into account and ignore the other contributions to wealth, growth and social cohesion.

The understanding of capital stocks as dynamic systems with elements and outputs characterised by weak comparability, and their interactions as essential for sustainable development can help to extend the perspective and to shed new light on the challenge which sustainability poses to economics. This is all the more true when the focus is on the dynamics and not on the inventory of elements of different capital stocks, as it should be.

2 An alternative approach to complexity

Nature, society and the economy are doubtlessly complex systems. It is a characteristic of such systems that their behaviour cannot be predicted from analysis of the system elements, like individuals or their representative agents, plus the starting conditions. On the contrary, the emerging properties of a complex system are the result of varying kinds of interactions of these elements such as pressure factors and thresholds, leading to non-linear behaviour (incremental changes causing non-incremental results) and time lags (even a period of no pressures can coincide with significant impacts as a result of earlier violations of system stability conditions). The interactions vary as human behaviour varies unpredictably (actors are neither fully rational, in particular not in the specific economic sense of being ruthlessly selfish), nor were the result of their interactions predictable even if they acted rationally. They are confronted with the dilemma of facing two aspects of reality, a natural and a social one, each with its own rationality and sustainability criteria. Both are essential for survival, but sometimes contradictory. In such cases, the subjective value system determines the choice between incommensurable options. Furthermore, both systems change fundamentally over time under the market laws (Polany, 1957, after Rammel and Staudinger, 2002) and the slower, delayed but inescapable feedback from the environment to the economic system. Finally, once a damage dynamic has been started, it cannot be stopped by simply ending the pressures; the system inertia leads to ongoing change, as the climate problem illustrates. System development patterns comprise all these effects in different combinations.

Predictions would only be possible if the system behaved in a linear, mechanistic fashion. In evolving systems this is only the case when the system is in a semi-stable state, close to its energetic minimum. Such stale systems tend to react to minor disturbances of this 'gyro state' with marginal changes. It is only in this specific situation that the usual marginal analyses come close to the system reality (a second, similarly stable mode of system behaviour analysed since two decades in systems science but not in mainstream economics is chaotic behaviour, which also permits a number of predictions regarding the future system behaviour). The analysis of complex system behaviour and evolution, somewhere in between mechanistic and chaotic models, is still in its infancy. Systems theory can be used to distinguish suitable and non-adequate scientific approaches to sustainable development, by defining the four dimensions as subsystems, and sustainability as enhancing the viability of the meta-system.

The standard way to assess the complexity of a system is by analysing the system rules. One way of doing so is to define rules which gradually, when applied in a cumulative manner, drive a system from a rather undefined to a deterministic state. The more the rules are differentiated, the more classes of systems emerge. However, this is only useful for the analytical process, if the character of the resulting systems is significantly distinct between the classes defined. From the different ways of defining rules and thus distinguishing classes, the formulation of Allen (2001) is particularly suitable for application to economic systems and theories (his heirarchy could be aggregated and otherwise restructured – (see e.g., Bossel, 1999) – but this would result in a loss of information relevant to the analysis presented here). He distinguishes five classes of systems with distinct behavioural characteristics by formulating five subsequently applied rules, which together result in maximum determination. Lifting them one by one changes the character of the system towards a less deterministic one, and the resulting types of systems can be compared to economic reality itself, and to economic theory.

As a result, different lines of economic argumentation can be shown to be associated with 'mental models' of different levels of complexity. This permits distinguishing of those kinds of models (and thus theories) which are capable of delivering a description of the economic reality which adequately reflects the underlying kind of system dynamics from those which are mismatches, not suitable for relevant analyses and predictions. The five system rules suggested by Allen (2001) are, simply expressed:

- it is possible to distinguish between 'the system' and 'its environment'
- all system components can be recognised and distinguished, permitting the understanding (analytically or intuitively) of their interactions
- the active system elements are all identical, or at least the range of their behaviour is normally distributed around the average (a condition for strong comparability)
- the individual behaviour of the system elements can be described by average interaction parameters (resulting in strong commensurability)
- the system develops towards a stationary equilibrium, permitting to define fixed relations of system variables.

2.1 Economics

A situation where all five rules apply represents a system with no structural change taking place. Such a system has no historical time (all interactions happen simultaneously), cannot but move towards its predetermined attractor (the equilibrium) and is unable to adapt its structure to changes in its environment. To a large degree, this is how neoclassical economics describes the economy: as a predetermined static system on its way to a well-defined and predictable future state. This permits rational decisions by allowing comparison of the system state before and after a certain action is taken, e.g., by cost-benefit analysis. Consequently, all five rules can be found in neoclassical economics, but only some of them, applied in the given hierarchical order, in institutional, evolutionary or ecological economics (Samuels, 1995).

Rule four characterises systems within which the individual behaviour of the system elements can be described by average interaction parameters which also define the numeraire for strong commensurability. In standard economics, this is realised by restricting the analysis to market exchanges and by assuming predictable behaviour patterns based on the identical motivations of selfish actors, the individual utility maximisation of the homo economicus. Systems to which rules one to four apply, but not rule five with its predefined equilibrium are best described by system dynamic models, providing a mechanical description of change. Unlike equilibrium models, for which the system defines the outcome, dynamic models can develop towards different stationary states. The result is path dependent, and the path which is chosen is determined by the starting conditions. Once started in a certain 'attractor basin', the model determines the development path toward the respective attractor, with no escape possible. The attractor itself can be constant or cyclical; Schumpeter (1928) describes such phenomena as short and medium term innovation cycles.

If only rules one to three, but not rules four and five are assumed to be valid, the result is a self organising system in which according to rule three the active system elements are all identical, or at least their range of behaviour is normally distributed around the average; thus strong comparability is assumed for all system elements and all problems. Traditional neoclassical economics makes use of this assumption, as differing individual demand and indifference curves can only be aggregated into one macro level curve (permitting determination of a well-defined societal utility optimum) under this condition. Only if the preferences and thus, the demand curves are identical (or normally distributed around the representative individual) and with proportional incomes, is aggregation theoretically possible (the SMD Sonnenshein-Mantel-Debreu conditions; for a critical assessment of their implications for traditional economics see Keen, 2001). Giving up this assumption would break up the assumed micro-macro-link, as macro phenomena could no longer be calculated as the aggregate of individual decisions. In such self organising systems, the possibility of the homogenous and not learning individuals to dissent from the average behaviour permits some actors to leave the attractor basin they started in, whereas the normal distribution of behaviour makes sure that this cannot happen for the majority. Nonetheless, the system development is no longer determined, as different attractors exhibiting different probabilities can be randomly chosen. Self organisation is a non-equilibrium phenomenon; the development path can change over time. However, this process is undirected, not based on learning but on stochastic variation plus the positive or negative influence from the system environment. Evolution happens on the system level; amplification of processes which received a positive feedback is one of the key processes of self organisation. In this sense, the system as such – unlike the actors in it – has a learning capability, but no reflection or anticipation capacity.

Giving up rule three lifts all restrictions on assumptions regarding actors' behaviour, leading to weak comparability or even incomparability. Behaviour can change any time, dependent on learning, external influences or spontaneously, in any direction. Evolution happens to the system as well as to its subsystems or elements; selection processes on all levels enhance the dynamics of the system evolution. Explorative, non-average behaviour drives such processes. The outcome of the evolutionary process is unpredictable, neither the system structure nor the starting conditions determine the results. As the behaviour of individuals is not predictable, neither in a determined nor in a statistical way (Keynes emphasised this in 1937, but for obvious reasons not in a systems analysis context), no micro foundation for the macro phenomena is possible. The analysis of evolving economic systems needs a macroeconomic theory unbiased by references to micro level mechanics, but reflecting the co-evolution with other systems like society, the environment and other economies (Costanza et al., 2001).

Table 1 Levels and mechanisms of evolution in biology and economy

	Biology				*Economy*	
Level	→	*Effect/mechanism*	⇔	*Effect/mechanism*	←	*Level*
Molecular	→	Mutations	⇔	Inventions	←	Individual
Genome	→	Recombination	⇔	Innovation	←	Company
Organism	→	(Sexual) reproduction	⇔	Structural change	←	Sector
Species/ system	→	Speciation by isolation	⇔	Structural diversification	←	National economy

Source: Own compilation.

In biological and economic systems, evolution works on several analogous levels, as illustrated in Table 1. Speciation, the development of competitive advantages, which since Ricardo is so essential in economics to argue the benefit of free trade, does emerge in biology only with (relative) isolation – without it, homogenisation e.g., by sexual exchange, tends to dominate. In standard economics, diversity is taken to be a result of resource endowments, neglecting the dynamics of the process. Like invasive species in biotic systems, economic invasions can be disruptive for the existing community, undermining its service delivery capability immediately or after a time lag required for getting adapted to the local circumstances.

2.2 Economies

The rules three, four and five can be shown not to be valid in real-world economic systems (in particular, if rules four and three are not applicable rule five cannot be so either). Regarding rule five, the development towards equilibrium, Sraffa could show nearly 80 years ago that the assumed decline of marginal cost and utility leading to equilibria is the exemption rather than the rule. Real world economies are non-equilibrium systems, exhibiting dissipative structures maintained by the transformation of low into high entropy resources.

As far as rule four is concerned, the economic actors are not identical homini economici, acting according to standardised interaction patterns (see e.g., Ecological Economics, 2000). The diversity and dynamic development trends inherent in paid and unpaid work, production and reproduction, and the physical or economic irreversibility of production and consumption processes (Perrings, 1997) rule out that 'individual behaviour of the system elements can be described by average interaction parameters' (Allen, 2001). Instead their interactions are complex, driven by changing motivations and developing highly variable patterns; strong commensurability does not apply.

Regarding rule three, the behaviour of economic actors does not conform to the condition of being identical or normally distributed i.e., strongly comparable (for consumer behaviour, see e.g., Reisch and Roepke, 2004). Neither is the average constant, nor the distribution necessarily symmetrical. Innovation and structural change are driven by non-identical behaviour. Although impossible under rule three, in reality, actors are learning and anticipating (despite all the mistakes they make in trying to do so). Whereas the identity of demands may have been a fact in certain social groups (tribes, casts, classes, religious communities) in the past, with individualisation, the range of situations where it can be assumed to be still dominant is converging to nil. As a consequence, rule three does not apply to human societies, in particular not to affluent consumer societies, and models based on it are not a suitable basis for analysing the economy and a rather safe guess for wrong predictions regarding future developments.

However, rules one and two apply to economies: it is possible to define their border lines (although not undisputed, for instance in the case of unpaid labour), and their elements can be identified and their interaction understood – at least that is what much of economics is all about. Thus complex evolving systems are the only ones to match the characteristics of the real economy. Neither self organisation models nor non-linear dynamic ones stand the test, but lest of all equilibrium models.

2.3 The mismatch

As pointed out, standard neoclassical economics is applicable only to economic systems where rules three to five apply, i.e., where consumer and producer behaviours are constant, and identical, where the interplay of actors is standardised, and where the system inevitably develops towards a predetermined and unchangeable equilibrium – at best, a rather specific subset of real world situations. Only for these, can economic theory make useful and reliable predictions. In particular, it is not up to the challenge of understanding the evolution of economies and thus, not sustainable development (even not in those derivatives where the rules four and five have been modified or abandoned). Evolution is unpredictable, not even probabilities can be calculated.

Although making restrictive assumptions is a legitimate scientific procedure, conclusions reached on this basis must not be applied to any system with a different behavioural dynamic than the one used for deriving them (i.e., where rules three to five do not all apply). Unfortunately, there are only relatively few non-equilibrium models – many models assume rules one to five to apply, most models include at least rule one to three or four (for an alternative see e.g., Bockermann et al., 2005). All these are overdetermined as compared to the development dynamics of the real system, and inadequate to describe or even predict the functioning of economic systems (except under assumptions valid only in quite rare circumstances). Although it is a matter of scientific rigour to examine the applicability of the theory to the situation before a using any specific theory and applying it, these specific assumptions are hardly ever made explicit and tested before a model is applied to reality. If this not done in a thorough and transparent manner, conclusions from the model are obscure and cannot claim scientific credibility: rigour in each detail does not compensate for sloppiness in the basics.

From these deliberations, three conclusions can be drawn:

- As for evolving systems such as the economy, the behaviour of individual actors cannot be aggregated into a macro figure either mechanically or statistically, and as the patterns of exchange between actors are variable and evolve as well, we need a revival of macroeconomics (and a microeconomic theory conforming to that, not vice versa).
- This cannot be a mathematically formulated theory (equations or algorithms), based on fixed relations of the system elements (including stochastic variations). Instead it must permit dynamic development based on uncertainty, unpredictable and chaotic futures as part of the possible scenarios. Such models can illustrate options, but can neither predict futures nor lead to the identification of unambiguously 'best' politics.
- System analysis can provide a basis for such models, as it offers the best available instruments to describe the behaviour and evolution of complex systems. However, as the results of system analysis are necessarily on a rather abstract level, they need to be brought down to earth by interpreting them through a renewed economic theory. Evolutionary and ecological economic thinking provide a basis for this endeavour, but they should be better aligned and the possible synergies more systematically exploited.

However, if standard theory cannot deliver any solid advice regarding politics for sustainable development, on what should economists base their recommendations? The attempt to proceed in a scientifically sound way causes a serious problem: as any model making clear-cut prognosis needs to assume a fixed relation between system parameters and thus strong comparability, the alternative is between using well defined mathematical formulae to provide an unambiguous result with ambiguous relations to reality, or to restrict mathematics to system analysis, and simulation models to the role of illustrations for certain assumptions, ending with ambiguous results having a clear relation to reality.

Numerous economists claim that in the discipline, arithmomorphism (the reliance on numbers) has gone too far (Peet, 1997). In this sense, sustainability science might serve as an antidote (comprising systems analysis, post-normal science, uncertainty and transition research, evolutionary and ecological economics, plus insights from political and environmental science, sociology, psychology etc) as a basis to derive suggestions on what policies for sustainability could look like (see e.g., Funtowicz and Ravetz, 1994; Munda, 1995; Köhn, 1999; Hans-Böckler-Stiftung, 2000; O'Connor, 2000; ICSU, 2002; Coenen and Grunwald, 2003; Ramos-Martin, 2003; Rammel, 2003; Rammel and van den Bergh, 2003, Spangenberg, 2003, 2005). Such sugesstions cannot claim to represent an optimal solution, as in complex systems, with more than one criterion to be taken into account for judgements, the necessary multi-criteria optimisation process with incommensurable criteria usually results in a range of options, not in an optimum solution. This would only exist if one solution were simultaneously superior to all others regarding all relevant criteria. Therefore decision making for sustainable development is in need of open, transparent and democratic *political processes*: they are needed to make a choice, based on informed preferences and responsibilities, for one of the sustainable options.

The following sections illustrate briefly how such relevant information, resulting in criteria and indicators for an economically and otherwise sustainable economy, can be derived.

3 System analysis, cybernetics, Orientor theory

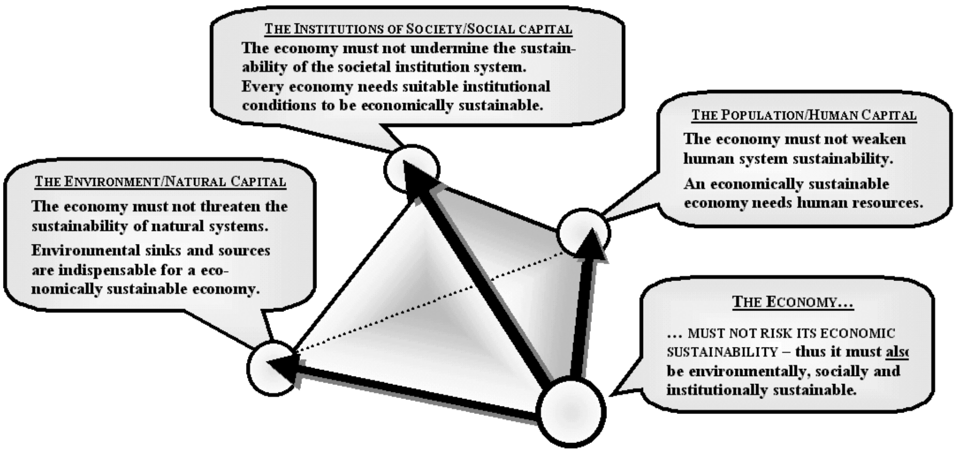
System analysis is a discipline analysing the common characteristics of systems in different spheres of life and dealt with by different lead disciplines, in order to identify commonalities, understand the system processes and use this knowledge to steer or guide the system development. Systems theory is thus aimed at system management and denies claims that steering is rather impossible (as for instance Hayek in economics or Luhmann in sociology have advocated). However, there are few applications of this rather abstract theory to multi-dimensional sustainability problems so far, and before using it to analyse the sustainability of economic development processes, sustainability must be defined for complex evolving systems.

The latter is the raison d'être of the Orientor Theory, the only theory available so far specifically for this purpose (Bossel, 1999). According to Bossel, maintaining the viability of a system is equivalent to its sustainability, and viability is maintained if a system is able to react adequately on changes in its system environment.

For sustainable development analysis, the system environment of an economy is set to comprise of four subsystems (population, society, the natural environment, and other economies, corresponding to the four dimensions or capital stocks discussed earlier. A sustainable economy must not undermine the sustainability of the systems it is interacting with while defending its own viability, i.e., the economic sustainability of the economy (see Figure 1 for an illustration of this impact relationship). As an analysis of the macro level system behaviour, it assesses the results of these actions and interactions, but does not analyse the system elements, their behaviour or motivations at the micro level. It helps to identify the characteristics of potentially sustainable systems, but does not claim to define a unique sustainable system structure.

The challenges posed by the system environment can by classified into six independent categories (none of them can be expressed by a combination of the others), which together describe the potential states. As has been shown by theoretical analysis (Bossel, 1998) and empirical research with a cluster analysis of about 200 social systems (Hornung, 1985), the list is comprehensive. To each of the challenges, the system must react by developing a specific capability, equivalent to the conditions for system sustainability, albeit still on a rather abstract level. If these characteristics of sustainable systems are interpreted from an economic perspective, building on the existing stock of knowledge without relying on non-applicable models (done here for the first time), criteria for the economic and general sustainability of the economy can be derived.

Figure 1 The sustainability interlinkages of the economic system



Source: O'Connor (2000) modified

These systems level criteria can be used to analyse by stringent or at least plausible argumentation, which specific criteria should apply to any economy regarding its interaction with the parallel systems. For instance, resource scarcity can refer to human resources; then an adequate education system, socialisation conditions, adult education and the contribution of the economy to this, either by paying fair taxes for a public system or by providing the institution itself would be relevant criteria.

For natural resources, the well-known management rules apply: do not use renewable resources beyond their regenerative capacity, and do not use non-renewable resources without developing substitutes of the same scale (here substitution refers to a process of replacing one resource by another, not by capital; for a different definition linked to a variety of measurement tools see Robert et al., 2002).

If the scarcity refers to the institutional dimension, the reliability of the legal and administrative system might be a case in point. It can be assured by combating corruption and by enhanced distributional justice (as this strengthens the respect for societal conflict management mechanisms, including property rights and the enforceability of contracts). The challenges and the corresponding capabilities (the Orientors, as they provide an orientation for sustainable system development) are listed in Table 2.

Table 2 Challenges, Orientors, and Key criteria

Challenges	*Orientors*	*Key criteria*
Normal state	Existence and reproduction: the system must be able to continuously exist and reproduce itself in the normal state of the system environment	Structural integrity, reliability of conditions for reproduction, supply of goods from the given resource base, markets, supply and demand, basic property rights, limited corruption
Resource scarcity	Effectivity: the system must be effective (not necessarily efficient) in providing essential resources	Capability to influence the natural, social and economic environment, securing access to vital resources
Diversity	Freedom of Action: As the system environment is not homogenous, the system must be able to cope with diversity of supplies, and also of challenges	The capability to react to a diversity of environmental states requires a corresponding diversity of system structures, processes, and resources used (natural, human, intellectual, technical and institutional resources)
Variability	Security: As the system environment is not constant, the system must cope with variability, i.e., states of the environment distant from the normal state	Security needs early warning and stress detecting institutions, robustness against minor or short term pressures (enhanced by redundancies) and resilience in case of more serious pressures. Repair-, control- and steering mechanisms are part of resilience
Change	Adaptability: As the system environment evolves, the system must cope with changes in the normal state of its environment by adapting its own structures	The capability to evolve as a reaction to external pressures is dependent on the innovation potential within the system, and the way it is realised. A diversity of options, not just one best, and redundancy are needed to be prepared when optimality conditions begin to change. Flexibility of institutions and reserves that can be managed for the change process is necessary
Other systems	Co-existence: Every system is dependent on exchange with its environment. Undermining the viability of the system environment is thus a lethal strategy	This refers to population, society and the natural environment as much as to other economies. Information exchange is essential for detecting risky developments, as is adequate information processing. Co-existence in co-evolution requires a principle of reciprocity

Source: (Bossel, 1996, 1998, 1999, 2000; Peet and Bossel, 2000, summarised, completed and modified)

In a similar manner, for all Orientors and all systems, criteria can be developed, which describe the sustainability of the economy. They differ from traditional economic success criteria by

- stressing the needs for diversity and redundancy of economic structures, processes and technologies
- emphasising the need for a balanced exchange with other economies in physical as well as in monetary terms, as otherwise, the co-existence orientor would be violated by undermining the effectivity orientor of other systems

- highlighting the innovation potential in its technical, economic, social and institutional perspective
- demanding adequate contributions to the quality of life, the viability of the institutions, social cohesion and a sound environment as *conditions for the economic sustainability* of the economy
- providing criteria for the social, institutional and environmental sustainability of the economy.

As a result of the analytic process and its economic interpretation, a system of indicators has been developed, permitting the assessment of the economic sustainability of an economy as well as its social, environmental and institutional sustainability more clearly and comprehensively than before (Spangenberg, 2005). The difference to the usually applied indicators is based on the above mentioned different criteria, adding for instance, measures of diversity, innovativeness, and co-existence with the system environment, which could have hardly been derived from standard economic thinking. A number of the usual economic indicators is reproduced by the analysis, but derived in a new way. The results also reiterate the importance of a fresh effort in macroeconomic thinking, in particular in the context of sustainable development, independent of micro-economic processes and in particular of standard theories, as these are not capable to adequately deal with the problems in question.

4 Discussion and outlook

Any policy based on a short-term maximum exploitation of easily available economic, human, social and environmental resources is obviously unsustainable, unless it is a part of some more comprehensive plan, which if it is to be successful must be based on some exploration of possible future paths of the economy. Comparing and assessing the models used for this purpose explores the sustainability capability of different theoretical approaches.

As the assumptions of both strong comparability and strong commensurability are essential to standard economics and its models, neither the theory nor the models are capable of dealing appropriately with the sustainable development of the economy. Only if the analysis is based on the concept of complex evolving systems, can an adequate understanding of sustainable development processes be achieved, with no commensurability and weak comparability characteristics of the systems under analysis. This is the domain of ecological and evolutionary economics. This paper has demonstrated the possibility of a new approach to the economic sustainability of economies by adding Bossel's Orientor theory to the tool box. Rather a blind spot so far (most papers talking about economic sustainability do indeed address the environmental sustainability of the economy), it would be of obvious relevance for economic policies if this or a similar approach were put into practice, not based on theories which cannot cope with the complexity of reality.

The next step following the definition of criteria is the process of deriving indicators, reducing the possible plethora to a suitable number, and testing this set by applying it to sustainability scenarios from different disciplines and actor groups (Spangenberg, 2005). A test has been conducted by analysing established economic theories to see what lessons might be learned from them, despite their lack of complexity. It can be demonstrated that the criteria and indicators resulting from them are all included in the Orientor-theory based analysis, which however provides a more comprehensive and complete set of criteria. This set can, in turn, be applied to existing sustainability scenarios to identify their weak points (missing themes, imprecise assumptions, etc) and to help develop more comprehensive policy strategies.

As describing these steps as well would go far beyond what can be presented in a single paper, they will be made public in future publications.

Acknowledgement

I am grateful to F. Luks, I. Omann, F. Hinterberger and S. Striewski who gave valuable feedback in the course of the project, which is the basis of this paper.

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Notes

[1]Some scholars do not claim that qualities do not exist, but assume that with the right framework conditions endless growth could also be environmentally and socially benign, i.e., sustainable (e.g., Hawken et al., 1999). A subgroup believes that this 'sustainable growth' will be achieved without policy intervention, through the equilibria produced by the market, as expressed in the discussions on the Kuznets and the Environmental Kuznets Curve (Agras and Chapman, 1999; James, 1999). In this case, other qualities would not need to be measured as they were dependent variables, implicitly covered when measuring the trends in aggregate economic output in monetary terms.

[2]However, from a four-dimensional perspective on sustainable development it should be mentioned that indeed monetary value is *one* criterion amongst other which can be applied (with all the methodological difficulties known) to all four capital stocks to assess their certain aspects of their economic sustainability, and that may permit useful answers for specific questions in this respect.

[3]See Fisher (1906) for a different and more systematic understanding of consumer satisfaction, in particular the role for past consumption for a sustained psychic income (Lawn, 2001). Although focussed on the micro level, this approach is much closer to the sustainability discourse, in particular to the analysis of sustainable consumption; the psychic income can be interpreted as a non-quantifiable measure of social sustainability.