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Sustainometrics: Measuring sustainability

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Abstract: The paper argues for the need of "sustainometrics", i.e. a science that studies, models and measures sustainable development, including measuring progress towards sustainability, measuring the status quo, benchmarking and best practices. There are already vast bodies of research as to how to study and measure the economic, social and environmental but we do not know how to study and measure the whole. To make things even more complex, this whole is dynamic as it is constantly co-evolving with its components. This often results in the emergence of unexpected properties, an example of which is climate change.

A new area of knowledge (and profession) is currently appearing which is sustainability. In order for it to inform policy decisions and guide human behaviour it will need to also develop its modelling and measuring tools (including sustainability indicators, ecological footprint and food miles among other) and information systems (local, regional and global), which sustainometrics should provide.

Keywords: *Co-evolution, global system, intelligent information system, sustainable development*

1. INTRODUCTION

The concept of "sustainability" has been associated with a wide range of human activities related to the use of resources, including natural, human and financial, implying long-term continuity and ability to carry on with these activities indefinitely (Marinova and Raven, 2006). According to Hasna (2007), sustainability refers to a development of all aspects of human life affecting sustenance. Since the mid 1970s the term has been laden with value judgements about justice in the distribution and use of resources. This was started by the World Council of Churches during its 1975 Assembly in Nairobi (Cobb, 1992), followed by the publication of Our Common Future (or the Brundtand Report) by the World Commission on Environment and Development in 1987, the 1992 United Nations' Earth Summit in Rio de Janeiro (which adopted Agenda 21) and continued through the adoption of the Millennium Development Goals by the United Nations' General Assembly in 2000 and the 2002 World Summit in Johannesburg. A lot of this political debate was fuelled by the evidence originating from the academic and scientific world as to what impacts climate change and environmental deterioration have on human and other communities.

The 2001 World Congress "Challenges of a Changing Earth 2001" in Amsterdam organised by the International Council for Science (ICSU), the International Geosphere-Biosphere Program (IGBP), the International Human Dimensions Program on Global Environmental Change (IHDP) and the World Climate Research Program (WCRP) proclaimed the birth of a new academic field, namely sustainability science, with strong roots in the environmental aspects of the sustainability concept (Kates et al., 2001). On the other hand, by that time economists, philosophers and ethicists among others had already started the pursuit of understanding concepts such as the limits to growth (Meadows et al., 1971), steady-state economics (Daly, 1991), weak and strong sustainability (Neumayer, 2003) and deep ecology (Sessions, 1995; Witoszek and Brennan, 1999). The United Nations 2005 World Summit in New York (a follow-up of the 2000 Millennium Summit) reaffirmed that the new area of knowledge development requires to be grounded in the "interdependent and mutually reinforcing pillars" (UN, 2005: 12) of simultaneously achieving economic prosperity, social development and environmental protection.

Hence, we have witnessed the establishment of a highly complex, vibrant and holistic new science which will be bringing together scholarship and practice (Clark and Dickson, 2003) shaping human understanding, behaviour, innovation, decision-making and actions in the years to come. Described as "use-inspired basic research" (Clark, 2007: 1737), this science is still in the process of defining and developing its analytic and scientific underpinning, approach, tools, objectives, aims and tasks.

This paper discusses methodological problems related to this emerging science before addressing the issue of modelling sustainable development for global systems. Based on a global system approach, the aim is to position the discussion within the context of co-evolution of the three widely accepted sustainability pillars, namely social, economic and environmental. The paper then critically analyses the concepts and modelling approaches adopted for presenting sustainable development. It argues that sustainable development and being sustainable are two separate characteristics of the complex heterogeneous systems representing society and the environment.

The two questions asked from a modelling perspective are: (1) are the theory and practice of modelling sustainable development adequate to what we currently know and need; and (2) how well are other approaches based on quantitative and statistical methods, such as econometrics, biometrics and sociometrics, equipped to serve the needs of sustainable development. In essence, the paper argues for the need of "sustainometrics", i.e. a science that studies and measures sustainable development, including measuring progress towards sustainability, measuring the status quo, benchmarking and best practices.

2. WHY SUSTAINOMETRICS

As early as in 1992, Pezzey (1992) published dozens of definitions of the term "sustainable development", including the most widely cited Brundlandt definition: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987: 43). Several years later Jacobs (1999) accepted that the concept would remain contested and politically fluid because of the different stances taken in relation to what can be considered "fair". The Western Australian State Sustainability Strategy states: "sustainability is defined as meeting the needs of current and future generations through an integration of environmental protection, social advancement, and economic prosperity" (Newman and Rowe, 2003: 24). Anand and Sen (2000) claim that sustainability is analogous to the concept of usufruct rights (i.e. the right to use another's property without changing its substance) extended beyond the economic realm to cover social and environmental aspects of human activities. The European Union's Network of Excellence on Sustainable Development in a Diverse World (www.susdiv.org/) added cultural diversity as another layer of the sustainability puzzle while UNESCO's 2005–2014 Decade of Education for Sustainable Development also includes gender equality and peace and human security as key action themes. Article 13, strategic advisers on risk associated with business responsibility, estimate that currently there are more than 100 definitions of sustainability and sustainable development (www.article13.com/static/definitions.asp).

This lack of consensus as to what exactly sustainable development refers to, is further complicated by the fact that "sustainable" is used to describe processes and activities (e.g. sustainable finances, sustainable business activities, sustainable student numbers, to mention just a few) which in no way represent or contribute to the complexity of issues needed to be understood and tackled in order to achieve long-term continuity and ability for humanity to carry out with its presence on the planet Earth. In other cases, activities are claimed to be "sustainable", such as sustainable tourism, sustainable agriculture or sustainable buildings, with limited ways to actually prove that this is the case within the full spectrum of the sustainability concept.

Against this complex and often conflicting background, what is urgently needed is a way to conceptualise, model and measure the progress that humanity is making towards becoming more sustainable. In other words, there is a need to establish and develop the tools and methods of sustainometrics.

Because of space limitation, only two arguments are presented as to why sustainometrics is essential in furthering our knowledge, namely: (1) the difficulties in modelling sustainable development and (2) the limitations of econometrics in its ability to contribute. Slightly different but in essence similar arguments can be mounted for the limitations of sociometrics, biometrics and other quantitative tools that we currently have.

2.1. Intricacies of sustainability and sustainable development modelling

The importance of modelling has been recognised since the mid 20th century (Bailer-Jones, 1999). According to Justi (2002: 369), "modelling – the production and revision of models – has been seen as the essence of the dynamic and non-linear processes involved in the development of scientific knowledge". The essence of mathematical, information and computer modelling implies the use of formal descriptions. They are an analogous abstraction of the reality as distinct to physical or social models based on the nature of things, such as the building of a small object representing a larger thing, an archetype, a representative of a sample or a person who is worthy of being imitated. Because of its detachment from the real world, the ability to create a model of the former type rests entirely in the clarity of understanding what exactly is being modelled. In other words, models that are created for an ill- or poorly defined area of inquiry, such as what is still the case with sustainable development, are unlikely not only to be trusted but also to be able to generate new knowledge. Their outcomes are not single-valued and can potentially be misleading. For example, they are likely to fail in such important areas as becoming a basis for assessment, forecasting and prediction (Rotherberg, 1989).

From a modelling perspective, the existence of so many definitions for sustainable development, on the other hand, is an indication of a positive trait. It manifests the academic popularity of the matter which is fully understandable given the high expectations as to what this newly emerging and complex area should deliver. In many ways, this is unprecedented in human history because of its complexity, urgency and need for cooperation. The climate change agenda alone provides possibly the biggest challenge ever for the research community as well as for policy makers (PEER, 2007).

As analogy and metaphor are essential to the development of an understanding of modelling (Gilbert, 2004), it is worth pointing out that the situation with sustainable development can be aligned with one of Zeno's paradoxes, that of the arrow. As sustainable development is that profoundly difficult to grasp with the attempts of the existing sciences, it creates the impression of the "motionless flying arrow". Zeno states that for a motion to occur, e.g. a move towards sustainability, an object, e.g. humanity, must change the position it occupies. In a single moment of time, the arrow cannot move to where it is not and cannot either move to where it already is. This time perspective is crucial to understanding any models for sustainable development and Section 2.2 elaborates further on this.

Bertran Russell's type theory (Russell, 1921) offers a different, equally insightful, perspective onto the situation with sustainable development. "Sustainable development" is a type 1 category, that is, it consists of a set of individual entities. If used as an adjective, i.e. sustainable, for other sets or systems such as finances or manufacturing, it would be referring to category type 0, that is an individual entity. Hence, the level of analysis for modelling sustainable development needs to remain within its own scientific domain. This is where sustainometrics can be of help.

The implications from the above two philosophical positions are:

• time is a crucial consideration, however the time horizon that we need to deal with should stretch beyong the “motionless flying arrow” effect;

• the study of sustainable development should remain at the global level, that is of type 1, which cover humanity, nature (or the physical environment) and the economy;

• any modelling should be able to capture the changes that are happening at the global level within the appropriate time horizon.

These three considerations represent the basic foundations of sustainometrics.

2.2. Econometrics and the century gap

According to Baltagi (2008), econometrics has experienced phenomenal growth in the last 50 years despite numerous criticisms in relation to the policy application of its mathematical models (e.g. Marinova, 1997). Its attractiveness is in what was perceived as its ability “to provide a substitute for the experimental method” (Morgan, 1992: 9) and make “temporal variations amenable to analysis” (Morgan, 1992: 9). The problem with the modelling of time series with a long horizon however is two-fold. Firstly, the modelling tends to represent the status and variables of the systems and not of the processes occurring in them. Secondly, it is not clear how informative are the status of the systems and the trends of their main indicators for forecasting long-term behavioural changes. The econometric methods and tools, such as unit roots and co-integration for example, deal with time series for periods of 20 to 40 years in order to analyse macroeconomic variables (Hatanaka, 1996). What are the implications for sustainable development?

The following are some further concerns that question the ability of econometrics to adequately serve the needs of sustainable development:

- Is it possible to manage sustainable development? If we are in a position to properly describe the current status quo or baseline, how can we gear the global model towards sustainability? The three global capitals that need to be simultaneously managed are economic, social and natural (Dyllick and Hockerts, 2002). Can econometrics which deals with only one of them inform decisions that require full integration of these aspects?
- According to Velasco (2008), we are yet to develop reliable and accurate econometric methods that can handle a time horizon longer than 100 years. The effects of sustainable development (or the lack of it) on the other hand manifest themselves exactly in a time horizon of this kind. Without ways to be able to understand and measure the changes on this scale, we will be locked in the “motionless flying arrow” paradox.
- The focus of econometrics is on the economic principles that affect the human species. In fact, it aims at providing empirical content and evidence to economic theories and/or subject economic theories to empirical tests. Sustainable development however has a much broader aim which covers more-than-human species and geo- and biodiversity. The three widely accepted pillars of sustainability are represented at a system’s level by “humanity” – social, “economy” – economic and “nature” – the natural environment (see also Figure 1). The global problems that humanity is experiencing at the moment, e.g. climate change or poverty, are the result of activities that have been carried out for longer than 100 years. They also point at the need to close the “humanity–economy–nature” system within the boundaries of the planet Earth. Econometrics deals only with the “economy” component of the system and without a way to understand and measure the entire system at a global level, Russell’s paradox is only bound to persist.
- Which component of the “humanity–economy–nature” system has the intelligence to guide the transition to and maintain a sustainability state? Humanity may be in a position to do so but so far there is very little evidence available for such a shift happening. In fact, most of the scientific evidence in relation to climate change (IPCC, 2007) points to the opposite, that humankind is on a road of destruction as far as its natural environment is concerned. Social disparities also continue at a global scale between the wealthy West and the poor developing countries (e.g. Chambers, 1997). They are strongly manifested in a country such as Australia whose Indigenous people have been excluded from the priorities of the “economy”-geared way of decision-making and policy development (Kinnane, 2002). The current financial crisis is another example of the lack of intelligence in guiding the global system (Shiller, 2008).

The intricacies of sustainability and sustainable development modelling, the “century gap”, the likelihood that it will persist and the limitations of econometrics can be understood even better when examined within a co-evolutionary perspective. This draws insights as to what approach is needed for humanity to accomplish its stewardship role on planet Earth by developing the required intelligence to do so.

3. WHY CO-EVOLUTION?

In recent years co-evolution has attracted a lot of attention as a concept which is yet to develop its full heuristic potential. Originated as an exotic ontological idea about universal interconnectedness, nowadays co-evolution forms the methodological basis for knowledge generation in a wide array of areas (Todorov, 2000). In biology it refers to changes occurring in one species or object (e.g. proteins) that trigger changes in other species or objects. Thompson (1994: 7) gives the following beautiful illustration of its power: “It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.” Other examples include co-evolution of languages, an area of cognitive sciences, and co-evolution of intelligent software in informatics.

A co-evolutionary approach implies the simultaneous self-development of humanity, economy and nature (see Figure 1) in its own trajectory (marked as) under the forces which generate their own development. It is unavoidable that the impulses produced by these three components of the global system would cause collision and contradictions. The latter require adequate adjustment and change (marked as 〈) which are outside the individual trajectories. In other words, the changes in direction, speed and size of development or evolution can only be understood in the context of the mutual interactions which become a joint process of evolution or co-evolution.

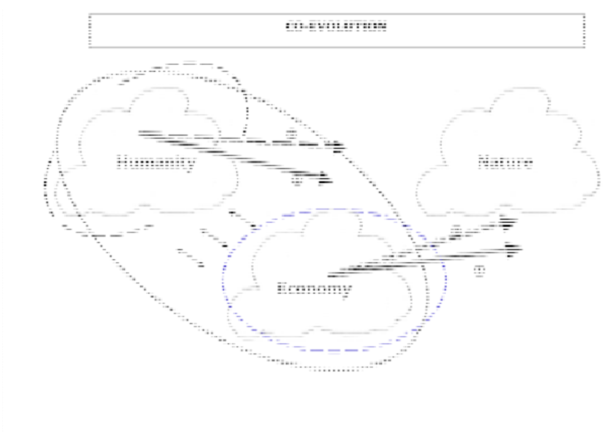

Figure 1. Co-evolution

Some important aspects of understanding co-evolution are:

- The co-evolving entities (i.e. the co-evolvents) are equally positioned in the evolution process. This implies that there is a need to balance and integrate all the value systems and decision-making that relate to environmental, social and economic priorities without compromising one for the other;
- The co-evolvents’ difference in nature makes them internally independent in the sense that each co-evolving entity is self-defined, has its own internal laws, rules and regulations that make it what it is and which are independent from the others’ internal laws, rules and regulations. The rules governing the economy are distinctively different to the ones influencing society and yet again very dissimilar to the ones describing the natural environment;
- The co-evolvents are externally dependent in the sense that each co-evolving entity can be informed and influenced by the others. In other words, changes that are happening within the economy affect society and the environment; similarly environmental changes affect human society and the economy and most importantly changes in human behaviour can affect the economy and the planet’s natural environment.

Hence, the mutual interaction and influence between the three systems are the necessary and sufficient condition for co-evolution to occur. Sustainometrics, including any modelling or measuring, needs to be able to grasp these co-evolutionary processes.

4. WHAT IS SUSTAINOMETRICS?

• Sustainometrics is the study of the global system of the Earth understood as a super-system above the global economy, humanity and nature.

• Its aim is to model and quantitatively measure the processes that are currently covered by other "metric" sciences, such as econometrics, biometrics and sociometrics. However, it relates them to the theory of co-evolution.

• Its methodology is based on information theory which allows the modelling of information processes occurring during interactions of intelligent systems.

The latter point requires some clarification. Information theory is based on the following assumptions:

- Information processes are real processes of system interactions;
- They are spontaneous and occur in an environment shaped by the interactions between the system's components;
- They are subject to the law of information relevance which is based on the system's hierarchy, nature and complexity.

Information theory requires information to be analysed as sets (triads) of the system's status related to generation, transmission and reception of information components described as semantics, syntax and pragmatics. The process itself is transformation and transmission of these states while the direction and content of the information process are determined by the information potential of the system, which in turn is indicative of its system diversity (please refer to Todorov, 2006 for further details).

Intelligence, understood as a non-psychological, non-epistemological category (implied by artificial intelligence), is a property of a particular type of systems (Todorov, 2006). Martin (2007) alludes about humanity having to deal with its own human intelligence but also with automated human thought and non-human like thought. This intelligence will be present in a new type of information machines which should be able to generate information processes with set-up up pragmatics.

In essence, sustainometrics is an information theory about the co-evolutionary modelling of global virtual realities with a time horizon spanning beyond one century whose main aim is to create global intelligent systems

5. CONCLUSION

We are yet to see the study of the global processes of sustainable development and their modelling using the co-evolution theory. What is however clear is that there is a need for a new area which would cover the study, modelling and measuring of sustainability allowing new knowledge to be generated that helps in analysing current trends, forecasting expected changes and managing the global system of "humanity–economy–society" for a sustainable development. We have taken the liberty to call this emerging area sustainometrics.

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