A framework for monitoring country sustainability

Un sistema per monitorare la sostenibilità di un paese

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Abstract
The development of systemic monitoring of country sustainability requires to tackle the complexity of human–environmental systems. To this end starting with a simple input/state/output scheme that shows the links among environment, community's economy/society and finally "real economy", we discuss on some more specific aspects of such scheme and we develop a classification of economies according to the proposed framework.

Abstract
Lo sviluppo di un sistema di monitoraggio per la sostenibilità di un paese richiede di affrontare la complessità del sistema uomo-ambiente. Partendo da un semplice schema di ingresso/stato/uscita che mostra il legame tra ambiente, società e "economia reale", si discute su alcuni aspetti specifici di tale schema e si propone una classificazione delle economie.

Key words: country disparities, economic development, socio-environmental systems, sustainability, cluster analysis.

1 Introduction

The concept of sustainability requires an integrated view of the world i.e. a multidimensional vision of the system that shows the links among environment, community's economy/society and finally "real economy". This framework can be

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used to describe a system, such as a country, and can be structured as a three concentric circle (Barbier, 1987) or as a three-storey pyramid, distinguishing between three levels. The base (third level) is the natural asset base which constitute crucial inputs into the system; the second level can be viewed as the state of the system, specifically the community's economy and society; the level 1 at the top of the pyramid is the real economy of the system.
In describing the pyramid, we actually refer to an input/state/output scheme, introduced by Coscieme *et. al*. (2013). In this framework a set of indicators must be introduced to monitor the country sustainability and particular specific indicators should be introduced for the input, state and output level. Considering this proposal as a first step towards developing a framework to monitor the country sustainability, it has been decided to introduce just one indicator for each level, specifically: Emergy per capita accounts for energy and matter inputs converging to a system (input level); Gini coefficient, as a measure of the inequality of income or wealth distribution, informs on the community economy of the system (state level); GDP per capita as expression of the economic value of the system. We know that no single indicator will suffice to identify and capture the multidimensionality of each level of the input/state/output framework (Eurostat, 2013). Yet, from a communication—and policy action—viewpoint, too many indicators can be confusing and moreover no agreement exists yet on an analytical framework or a set of indicators to monitor green growth (Green Growth Knowledge Platform – GGKP, 2013). With the aim of classifying a possibly large set of countries based on the above mentioned indicators, we have to face the difficulty of recovering data, being aware that these are not always truly comparable.
The paper follows this scheme: section 2 is concentrated on the state block, specifying a list of possible indicators that reasonably could be used to monitor the state of the system; section 3 deals with issues referring to the recovering of the proper information and their comparability. Finally section 4 classifies national economies and section 5 presents some final remarks.

2 The state of a system

Starting with the representation of an economic system by means of the input-state-output scheme described in Coscieme *et al.* (2013), the present section intends to focus on the indicators of the state of a system. Though in this preliminary study the state of the system is accounted for by just one indicator, that is the Gini index, the discussion should involve the whole socio-economic context as well as the policies and economic potentialities of a society.
In the framework of sustainability, the social dimension is to be viewed as a basic pillar, strictly linked with the environmental and economic dimensions. In particular social inclusion, social justice and social equity, together with economic development and environmental protection, are recurrent keywords in the definition of strategies towards the improvement of quality of life through such concepts as

green economy and green growth (UNEP, 2011; World Bank, 2012). At the European level, the Europe 2020 strategy has defined as priorities the targets of a smart, sustainable and inclusive growth (European Commission, 2010).
When representing the organization of a system in terms of its socio-economic context, a set of indicators should be introduced. The list of possible indicators can be broadly grouped into the following categories: i) labour market rates; i) measures of inequality; iii) indicators of social exclusion; iv) measures of equity.
The employment/unemployment/activity rates account for the work capacity in the production process and they determine the work intensity within households.
The Gini coefficient, as a measure of the inequality of income or wealth distribution, informs on the extent of the unbalances in the allocation of monetary resources.
The indicators of social exclusion investigate the vulnerability in terms of poverty, material deprivation, access to such services as education, health and sanitation.
The equity principle is intended to bridge any discrimination, i.e. between the sexes, between age groups and between natives and immigrants.
The indicators of socio-economic context may be seen as the result of the organization and structure of a system through the decisions regarding the allocation of the public expenditure in the framework of the welfare system. They in turn can drive the choice of adequate policies for social, economic and environmental performance.

3 Data and gaps

Statistical information plays an important role in the application of the framework for monitoring country sustainability because the availability of the above mentioned indicators is a *conditio sine qua non* to obtain a reliable representation of the reality and to apply the proposed method. Therefore one of the broad goals of this paper is to establish the feasibility of appropriate comparisons across countries based on good quality data.
The input measure of the system is the Emergy per capita, computed as the ratio between total Emergy and population. The Emergy Evaluation is an environmental accounting method of the use of resources in a given system on the basis of a common physical unit, equivalent solar energy. It provides data on the basis of classes of resources (renewable or not; local or imported) and indicators. The indicator is drawn from the National Environmental Accounting Database (NEAD)[1] which represents the most suitable source of information since it compiles detailed information for 169 countries about the full array of resources that underlie economies (Sweeney, 2007, Cohen *et al*, 2006). The framework for Emergy analysis at the national scale is well defined, using tables of quantified system inputs, and standardized calculations of aggregate flows and indices to summarize

[1] For more detail on this database see the project website http://sahel.ees.ufl.edu.

condition (Odum, 1996). This analysis exploits the most recent information that refers to the year 2008.

Perhaps the oldest approach for measuring the general socio-economic conditions of a population is to employ macro social indicators. These are generally derived from national level administrative data. The World Bank hosts a wide array of online databases and datasets that cover a broad range of development issues. One of these is the World Development Indicators (WDI) that presents data from all countries within a standardised framework. Even if WDI is global in scope, however the data availability varies by indicators and over time and moreover it is limited for some countries. This database is used for retrieving the information for the year 2008 on both the per capita GDP, in Purchasing Power Parity, and the Gini index. However, for the latter indicator a more complete list that covers more countries can be found by using the "All the Ginis" database (Summer 2013 version)[1]. This database represents a compilation and adaptation of the Gini coefficients retrieved from eight sources (Luxembourg Income Study-LIS, Socio-Economic Database for Latin America -SEDLAC, Survey of Living Conditions-SILC by Eurostat, World Income Distribution-WYD, World Bank Europe and Central Asia dataset, World Institute for Development Research-WIDER, World Bank Povcal, and Ginis from individual long-term inequality studies) in order to create a single "standardized" Gini variable. Whenever the Gini value for the year 2008 was found neither in the WDI database nor in the All the Ginis database, it has been imputed from the average values of the available Gini indexes of the adjacent years from WDI dataset (Gini imputed). Moreover the Gini index for Australia, New Zealand and USA is collected from the OECD data base and included in the category "Gini imputed".

Table 1: Data availability: number of countries by source of information

Indicator	*NEAD*	*WDI*	*GINIS*	*Gini Imputed*	*Merging of datasets*
Emergy	99				
Gini		49	84	124	
Gdp		180			
Emergy+Gini+Gdp					99

In Table 1 the number of countries whose data are available is reported for each single indicator and for a combination of them.

4 Country classification through a cluster analysis

Cluster analysis is a numerical technique that is suitable for classifying a sample of heterogeneous countries in a limited number of groups, each of which is internally

[1]Further detail on this database can be found at http://econ.worldbank.org/projects/inequality

homogeneous in terms of the similarities between the countries that are included in the same group (Everitt *et al*., 2011).

Taking into account that our goal is to provide a classification that is reasonably "objective" and "stable" in the sense that the analysis of the same set of countries by the same numerical method produces similar classification; and stable in that the classification remains similar when new countries –or new characteristics describing them– are added, cluster analysis is a more nuanced and objective statistical technique for the composition of groups of countries than the mere 3-axis diagram previously introduced (Coscieme *et al*. 2013). Moreover, it would allow to include a more complete set of indicators that better reflects the multidimensionality of the scheme.

In the empirical analysis a non-hierarchical cluster analysis has been applied using the available information on the set of indicators covering the proposed scheme, that is the per capita GDP, Gini index and Emergy per capita indicator.

Prior to clustering data, the variables have been rescaled for comparability. The clustering method chosen is the K-means (the most popular partitioning method), which requires the analyst to specify the number of clusters to extract. For choosing the appropriate and useful number of clusters the Calinski-Harabasz's rule has been applied, which is based on the F ratio between the mean square of the between-group dispersion and the mean square of the within-group dispersion.

The findings suggest a classification of the 99 countries into five groups. The following groups have emerged.

The group 1 "Strong unequal and poor economies with low natural resource dependence" (Bolivia, Brazil, Chile, Colombia, Ecuador, El Salvador, Guatemala, Jamaica, Mexico, Namibia, Nicaragua, Nigeria, Paraguay, Peru, Rwanda, South Africa, Suriname and Zambia) includes countries with lower than average Emergy input, poor economic performance and strong disparities. The majority of countries included in this group are ecological creditors in that their biocapacity is greater than their Ecological Footprint.

The cluster 2 "Natural resource dependent countries with high economic development" (Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, New Zealand, Oman, Portugal, Saudi Arabia, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom and USA) is a more numerous group characterized by the second highest values for both GDP per capita and Emergy together with a lower than average Gini index. This group includes a large share (81 percent) of countries that are ecological debitors, i.e. whose Ecological Footprint exceeds their own biocapacity.

The group 3 "Environmentally, socially and economically medium economies" (Albania, Algeria, Argentina, Armenia, Azerbaijan, Belarus, Belize, Botswana, Bulgaria, Croatia, Guyana, Israel, Kazakhstan, Latvia, Lithuania, Malaysia, Poland, Romania, Russia, Thailand, Turkey, Ukraine, Uruguay and Venezuela) is composed of countries sharing average values of all the indicators.

The group 4 "Developing economies with lack of resources" (Burundi, Cambodia, China, Cote d'Ivoire, Colombia, Egypt Arab Rep., Ethiopia, Guinea, India, Indonesia, Jordan, Kenya, Madagascar, Malawi, Mali, Mauritania, Moldova,

Morocco, Mozambique, Niger, Pakistan, Philippines, Senegal, Sudan, Syrian Arab Republic, Tanzania, Tunisia, Uganda, Vietnam and Yemen) represents country systems showing the lowest Emergy values together with the lowest economic output uniformly across countries, in combination with an average level of inequality.
Finally the cluster 5 "Strong natural resource dependent countries with very high economic development" (Australia, Austria, Belgium, Canada, Netherlands and Norway) is the smallest group that benefits from the highest per capita GDP, the highest Emergy input and the lowest inequality.

5 Final remarks

In this paper we remark that any attempt to improve our knowledge about world-countries disparities under a sustainability viewpoint should face several challenges that is the discussion on the general framework, the choice of proper indicators and finally a number of problems in providing standardized and reliable statistics from different national systems. In this setting we explored the potentiality of a input/state/output scheme and we propose a first attempt of classification of national economies beyond the mere 3-axis diagram over-mentioned in the previous section.

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