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# Welcoming uncertainty: A probabilistic approach to measure sustainability

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ABSTRACT

Current efforts to build Sustainable Development Measurements have stumbled with problems of arbitrary structure, valuation, artificial ignorance suppression, and democratic illegitimacy. This paper proposes a new method to track and compare the Sustainable Development (SD) of countries, building an Interval of Sustainable Development (ISD). The ISD is capable of overcoming these problems by reporting all possible structures instead of only one, by relying on a variety of existing economic, social, and environmental variables, by embodying confidence levels in the measurement itself, and by facilitating democratic deliberation. By doing this, the ISD is capable of showing, subject to a confidence level, how a country is performing with respect to SD. This paper also applies this method specifying parameters and using available data for 180 countries during 1990–2011. During this 22-year period, results for a selection of countries are presented to illustrate the advantages and limitations of this proposal.



## 1. Introduction

At its beginning, the concept of Sustainable Development (SD) emerged as a response to mounting concerns about the environmental impacts of economic activity (Meadows, 1972; UN, 1982, 1992; WCED, 1987). With it became at least conceptually possible to harmonize the idea of endless growth with the preservation of a healthy environment. Soon after, the concept was expanded to include a third dimension, the social pillar of SD (IUCN et al., 1980), which has been widely accepted in many reports (The World Bank, 2006, 2011; UN, 2002, 2012). Today, the triple bottom line has been widely recognized in academic circles, business communities, and political spheres (Moldan et al., 2011; UN, 2015b; WBCSD, 1999; WEF, 2002).

The challenge of measuring SD has been at the core of concerns related to this frameworks wide adoption as a relevant public policy tool (GRI, 2002; KEI, 2005; SOPAC and UNEP, n.d.; UN, 1992, 2015a; UN, 1992, 2015a). Accordingly, a truly remarkable plethora of SD measurements (SDM), summarizing the complexity of multidimensional development processes (Godfrey and Todd, 2001; Warhurst, 2002) have been proposed as a way to measure it (Bandura, 2008; Eurostat, 2007; Riley, 2001; SCOPE, 2007; Singh et al., 2012; Tasaki et al., 2010 ; UNEP, 2008). One overview of SDM presents 41 proposals (Singh et al., 2012), the UN commission on Sustainable Development uses a list of roughly 140 (CSD, 2001), and the Compendium of Sustainable Development Indicator Initiatives has grown to include over 600 initiatives.

Yet, in spite of these efforts, current SDM have not become relevant policy making tools (Hak et al., 2016). This, at least partially, can be due to the fact that to date four problems remain: many SDM lack a theoretical basis, which implies an arbitrary structure (Böhringer and Jochem, 2007; SCOPE, 2007). Others, while having a theoretical basis, use concepts that are virtually impossible to value (UHU-IHDP and UNEP, 2012). All of them, by giving single values, artificially suppress the ignorance involved in the measurement of highly complex phenomenon (Giampietro and Allen, 2006; Rosen, 2000; Sarewitz, 2004), Finally, SDM are usually built with a notable lack of a meaningful democratic process, which makes them socially illegitimate even if technically robust (Bell and Morse, 2008; Hagan and Whitman, 2007; Kovacic and Giampietro, 2015).

These problems (arbitrary structure, valuation, artificial ignorance suppression, and illegitimacy) undermine the capacity of any SDM to guide public policy towards SD by raising questions about the robustness of their results, constraining their applicability, making them potentially misleading, and diluting their external

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relevance. If a SDM has an arbitrary structure, results can be easily questioned and change significantly upon modifications of assumptions. On another hand, it is straightforward that if a proposed measurement cannot be valued properly it cannot be very useful. By giving precise numbers, SDM can give the impression that trends and rankings are precise and reliable images, whereas ignorance (van der Sluijs, 2005) is surely present in any work related to SD. Furthermore, if a measurement is not socially recognized, even if technically sound, it will be of little use.

In this paper we propose a method to build a non-structural SDM named Interval of Sustainable Development (ISD). This method has the uniqueness of, lacking a precise theoretical basis, overcoming the problems of arbitrary structure and artificial ignorance suppression, while avoiding the problem of valuation and presenting a straightforward path towards social legitimacy.

By not imposing a specific structure, but allowing for all relative weights and a general Constant Elasticity of Substitution (CES) functional form, this method is capable of indicating without regard to structure how a country is performing. Also, the measurement builds upon existing variables and thus it is readily positioned to be used. Further, by not reporting one value but thousands of them in confidence intervals, the method changes the measurement and thus the concept of SD from deterministic to probabilistic, which is likely to be a step forward (Ciuffo et al., 2012). Finally, by allowing for a broad and flexible amount of variables it facilitates democratic construction.

The type of assertions the ISD allows for are not that a country is better off than another, or that it is approaching or distancing from a SD situation. The probabilistic shift implies that the only thing that can be said is that it is more or less likely that a country is faring better than another, or that is becoming more or less likely that it is in a SD path.

The remainder of this article is organized as follows. Section 2 formally presents the requirements for sound SDM, and extends the understanding of their usual problems. Section 3 applies the proposed method to obtain a non-structural SDM, the ISD. Section 4 shows the application of the method with specific parameters and data, and a discussion about them. Finally, Section 5 presents concluding remarks.

## 2. Requirements and problems of SDM

### 2.1. Requirements

There are many requirements for the construction of an adequate SDM, and problems with existing proposals stem precisely from their incapacity to comply simultaneously with the most important ones (Atkinson et al., 1997; Böhringer and Jochem, 2007; Brown, 2009; Hák et al., 2016; Hodge and Hardi, 1997). A broad review of requirements allows for their grouping in 3 categories: Theoretical basis, selection and treatment of data, and policy relevance together with democratic legitimacy.

#### 2.1.1. Theoretical framework

SDM must include the definition of SD at the beginning of its formulation, integrating environmental, economic and social aspects (Bossel, 1999; Miller, 2007; Ness et al., 2007). The theoretical framework, based upon this definition, should be able to discriminate between sustainable and unsustainable paths, and give guidance regarding to what elements contribute to SD and how do they interact.

However, these frameworks should be cautions not to excessively simplify the object of analysis, and not to underestimate the complexity of the interaction between the natural and socioeconomic systems they intend to understand. Oversimplifications can lead to deficient construction of SDM and misleading interpretation of their results. To avoid this risk, outputs should be seen only as approximations to the understanding of SD, allowing for the ignorance that comes with addressing very complex objects of analysis and deficient theoretical frameworks (Hukkinen, 2003; Stiglitz et al., 2009; van den Bergh, 2007).

#### 2.1.2. Selection and treatment of data

SDM, in this respect, share the same requirements than any multidimensional measurement, be it of poverty (Alkire and Foster, 2011; Anand and Sen, 1997; Bourguignon and Chakravarty, 2003), competitiveness (Bebbington et al., 2007; Porter et al., 1999 ; Schwab and Sala-i-Martin, 2014), environmental quality (Moldan et al., 2012; Prescott-Allen, 2001; Tyteca, 1996), among others.

They must stem from well-established data sources and consider meaningful variables representing multi-dimensional fields (Brown, 2009; Hak et al., 2016; OECD and JRC, 2008). Also, they require a specific structure, which comprises the selection of variables to be used, their normalization to make them comparable, a weighting structure to determine their internal relation, and an aggregation function to merge them into a unique value (Cash et al., 2003; Custance and Hillier, 1998; Parris and Kates, 2003).

#### 2.1.3. Policy relevance and democratic legitimacy

SDM need to be theoretical and methodological frameworks, as well as useful public policy tools (Barrios and Komoto, 2006). In particular, measurements should be relevant to policy process by providing enough information for policy making. To do so, they must be intelligible and easily interpreted in the sense that it has to be obvious what they are measuring and what their outcome means.

Moreover, a SDMís policy relevance cannot be achieved solely through solid internal coherence. SDM will be more effective in influencing policies as long as measurements are perceived by stakeholders not only to be relevant, but also democratically legitimate (Brito, 2012; Hak et al., 2016; Sachs, 2012). Thus, legitimacy becomes a crucial feature of any SDM, which is built through the perception that results have considered divergent beliefs, views, and interests of society.

### 2.2. The problems

The majority of requirements to build a SDM have been overcome by existing proposals, yet there are two that have not been able to be satisfied simultaneously, a third that has been usually overlooked and a fourth which is determinant for policy making.

This first one is that SDM usually lack a precise theoretical basis, which makes their structure arbitrary. The second is that theoretically sound framework that overcome the problem of arbitrary structure sacrifices the applicability of the measurement itself by using concepts which are virtually impossible to value. The third problem arises from the fact that in the vast majority of proposals, the measurement simply shows a single-value output, which artificially suppresses the ignorance that is undoubtedly present in any SDM. Finally, most measurements are not subject to democratic deliberation, which reduces their legitimacy and policy relevance.

#### 2.2.1. Problem of arbitrary structure

The structure of any SDM, and more generally any multidimensional measurement, consists in 4 steps: the selection of variables, normalization procedure, weighting definition and the selection of a functional form to merge variables into a unique measure.

The selection of variables which form the basis for many so called SDM is usually far from reflecting the multidimensional concept of SD, thus making them only multidimensional measurements of environmental quality (WEF, 2002). In other cases,