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A Review on the main Countries' Environmental Rankings

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ABSTRACT: A lot of people think that the economic development of a country is associated with its Gross Domestic Product (GDP), but GDP does not consider aspects as important as the environmental performance of a country. Nowadays, environmental issues are one of the most important aspects of the long term development of a country and play an important role in a nation's wealth. Although the analysis of countries' environmental performance is a very novel subject, many researchers are making a significant effort to capture its essence by testing the sustainability of regions. This paper discusses the main proposals developed in the literature that establish country rankings considering different dimensions in order to measure the sustainability or environment. This summary allows us to establish the main differences between proposals and some future research. Furthermore, we analyse the correlation and concordance between the different countries rankings established in the literature. The results reveal clear concordance between proposals.

Key words: Concordance, Countries, Environment, Ranking, Non-parametric measures

INTRODUCTION

Country performance cannot be limited to GDP alone. This measure is unable to capture the inequalities between countries, as it only considers the economic dimension of welfare, neglecting social and environmental aspects that are one of the most important conditions of the long term development of countries. As GDP ignores everything that happens outside the realm of monetary exchanges, it does not consider well-being. The United Nations Conference on Environmental and Development held in Rio de Janeiro in 1992 highlighted the goal of sustainable development indicators. The concept of sustainable development (SD) has become an important objective of policymakers. The Brundtland report defines sustainable development as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development (WCED), 1987; 41). Pope et al. (2004) establish that the triple bottom line covering the environmental, economic and social dimensions is the starting point for sustainability assessment. In the current economic scenario, the changes in this triple line are the subject of debate and concern on behalf of international organisations and governments all over the world. Dietz and Neumayer (2007) differentiate two forms of sustainability: strong sustainability asserts that ''there are natural systems which cannot be eroded or destroyed without compromising future generations' interests'' and weak sustainability asserts that it is possible to offset the loss of such resources with ''man-made substitutes…''. In this sense, several papers in the specialised literature use different types of indicators to assess sustainable performance or its three aspects: economic, social and environmental performance, although most provide country rankings without actually measuring environmental capital. Among these proposals, it is worth highlighting the Pressure-State-Response (PSR), Ecological Footprint (EF), Environmental Sustainability Index (ESI), Dashboard of Sustainability (DS), Barometer of Sustainability (BS), The Gallup-Healthways Well-Being Index (WBI), Genuine Progress Indicator (GPI), Index of Sustainable Economic Welfare (ISEW), City Development Index (CDI), Human Development Index (HDI), Human Sustainable Development Index (HSDI), Environmental Vulnerability Index (EVI), Environmental Performance Index (EPI), Living Planet Index (LPI), Environmentally Adjusted Domestic Product (EDP) or Green Net National Product (GNP), Genuine

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Saving Index (GSI), Sustainability Assessment by Fuzzy Evaluation (SAFE), Sustainability Society Index (SSI), Proportional and absolute composite environmental (pENV and aENV) and Well-Being Index (WI).

In the 1960s and 1970s, the early modern environmental movement assumed that economic growth was inevitably correlated with environmental degradation considered as a zero-sum choice. This consideration implies that limiting economic growth is the only way of preserving the environment or combating environmental devastation as an inevitable consequence of economic expansion. The 1980s saw the emergence of the concept of sustainable development and the recognition that economic growth could be ''decoupled'' from environmental damage (Dryzek, 1997). This recognition has resulted in the relationship between economic growth and environmental sustainability receiving a great deal of attention from researchers since the early 1970s. Various alternatives have been considered to measure sustainability in this relationship, although most are focused on air pollution and water pollution (Carson *et al*., 1997; Cole *et al*., 1997; Lists and Gallet, 1999; Bhattarai and Hamming, 2001; Lee, 2005; Binder and Neumayer, 2005; Liu *et al*., 2007; Song *et al*., 2008). However, the environment includes other factors as well, such as biodiversity, the ecosystem, natural resource and energy efficiency, etc., which are also important for maintaining environmental sustainability as a whole. One possible solution is to consider one of the indicators proposed in the literature, but researchers have to decide which one to use to measure sustainability. Lee *et al*., (2005) and Alam and Kabir (2013) used the EPI while Atil (2013) used the GS. Therefore, the main goal of this paper is to analyse several indicators proposed in the literature, because no single indicator is universally accepted, in order to verify whether or not there are significant differences between the results or rankings established by these proposals. In this sense, should not be forgotten that the lack of a universally accepted indicator has been justified by authors such Parris and Kates (2003) for three reasons:

a) The concept of sustainable development is ambiguous.

b) Plurality of purpose in characterising and measuring sustainable development.

c) Confusion over terminology, data, and methods of measurement.

Thus, in the Sections 2 and 3 we show the main proposals in the literature to measure environmental performance based on country rankings. However, the objective of this paper is not to extensively review the proposed indicators, as this task has already been performed by Böhringer and Jochem (2007), Singh *et al*. (2009) and Mori and Christodoulou (2012) among others. Section 4 analyses the correlation between the existing indices of environmental performance using Spearman's and the Kendall Tau rank correlation tests. Finally, Section 5 presents the main conclusions of the paper.

MATERIALS & METHODS

Although the analysis of environmental performance is a very novel subject, an increasing number of researchers are making a significant effort to capture its essence by testing the sustainability of regions. In this sense, we discuss the main proposals developed in the literature to establish a country ranking considering different dimensions in order to measure sustainability or environmental performance. Bearing this in mind, it is worth highlighting the following indicators:

Ecological Footprint (EF). The concept and calculation method was developed by Wackernagel (1994). Ecological footprint compares human demands on nature with the biosphere's ability to regenerate resources and considers four categories: carbon, food, housing and goods and services. The EF is measured in a normalised measure of land area called global hectares (gha). Thus, as the calculation of EF is based on data from national consumption statistics, it is first necessary to normalize data in order to convert any consumption into land use. Taking into account the comparability of scales and using the classes of scales identified by Ebert and Welsh (2004), the EF uses ratios that are not comparable. The weighting is equal for all components and aggregation is carried out by adding up all land and water requirements. The EF assesses environmental burdens, but it does not explicitly consider economic aspects and does not take into account social equity at all. As a result, the triple bottom line of sustainability is not considered.

The EF is an indicator of strong sustainability that assumes substitutability of different forms of natural capital, because it assumes different natural capital goods are additive in terms of land area (Dietz and Neumayer, 2007). Furthermore, the EF can be used to explore the sustainability of individual lifestyles, goods and services, organisations, industry sectors, neighbourhoods, cities, regions and nations, so it is now widely used around the world as an indicator of environmental sustainability. More details about it are available at www.footprintstandards.org.

Environmental Sustainability Index (ESI). This index was developed by Yale and Columbia Universities, the World Economic Forum and the European Commission and it aims to help achieve goals of sustainable long-term development. The ESI is a composite index tracking socioeconomic, environmental, and institutional indicators that characterise and influence environmental sustainability on a national scale (Esty and Cornelius, 2002). The ESI report was calculated for the Pilot 2000, 2001, 2002 and 2005. The last ESI in 2005 used 76 variables aggregated into 21 indicators of environmental sustainability grouped into five components (environmental systems, reducing environmental stresses, reducing human vulnerability, social and institutional capacity and global stewardship) considering a total of 146 countries. The indicators and variables included in the ESI reflect the concept of the triple bottom line of sustainability. The ratio-scale of the ESI is not comparable (Ebert and Welsh, 2004), therefore, the data are normalised. For the aggregation, it uses a weighted arithmetic mean, where all weights are the same and take only partly the viewpoint of strong sustainability, as the summarised outputs are provided by a composite index that is based on weak sustainability (Böhringer and Jochem, 2007).

Environmental Performance Index (EPI). The EPI emerged in response to a shift in focus by the teams developing the ESI. The EPI uses outcome-oriented indicators and was first calculated in 2006. The EPI quantifies and numerically benchmarks the environmental performance of a country's policies that can be more easily used by policymakers, environmental scientists, advocates and the general public. The EPI includes several indicators of environment that they are interesting for making decision in every country (Cimpoeru *et al*., 2011). Four EPI reports have been released to date, in 2006, 2008, 2010 and 2012. The last ranks 132 countries on 22 performance indicators spanning ten policy categories. It builds on measures relevant to two core objectives: reducing environmental stresses to human health and protecting ecosystems and natural resources (Emerson *et al*., 2012). The EPI focuses on the environmental dimension of sustainability, but does not consider the social and economic dimensions. All variables are normalised to a scale from zero to 100, where 100 is the target, weightings are drawn from statistical mechanisms (Principal Component Analysis) or by consulting experts (Böhringer and Jochem, 2007) and the index is obtained with the weighted sum. Finally, the index takes the view of strong sustainability. More information about the ESI and EPI indexes is available at: http://epi.yale.edu/.

Genuine Savings Index (GSI). This index is also known as Genuine Saving (GS) or Adjusted Net Saving (ANS). Genuine savings is a simple indicator devised by World Bank's researchers to assess an economy's sustainability. The GSI was published in 2008 and is a modification of the GDP deleting the capital depreciation, the resource depletion and the environmental degradation. The GSI converts all values into monetary terms, such that aggregation is again achieved by simply adding up variables with the same weighting. However, the indicator is usually measured in percentage form by dividing GSI by Gross National Income. This index takes the viewpoint of weak sustainability and more information about it can be consulted at: http://web.worldbank.org/.

Sustainability Assessment by Fuzzy Evaluation (SAFE) was introduced by Phillis and Andriantiatsaholiniaina (2001) and developed further in Andriantiatsaholiniaina *et al*. (2004), Kouloumpis *et al*. (2008), Phillis and Kouikoglou (2009) and Phillis *et al*. (2011). It is a model for the numerical assessment of sustainability that uses fuzzy logic reasoning and 75 basic indicators for 128 countries for the period 1990-2005 depending on data availability. The data are normalised by assigning the value 0 to the least desirable indicator values and 1 to the most desirable indicator values or targets. Therefore, the model provides an overall sustainability index of [0, 1]. In order to calculate this index, fuzzy logic avoids the use of weightings that are often arbitrary or cannot be easily extracted from a decision maker. More information about SAFE is available at: http://www.sustainability.tuc.gr/.

Sustainability Society Index (SSI). This index has been compiled since 2006 by the Sustainable Society Foundation (SSF), a non-profit organisation and is updated every two years (the latest edition being in 2012). The SSI uses 24 indicators for 151 countries structured in 8 categories that integrate 3 wellbeing variables: Human, Environmental and Economic wellbeing. However, the 2012 edition is slightly different following the audit by the Joint Research Centre of the European Commission, which recommended some adjustments be made to the framework. Aggregation is performed from indicators into categories and from categories into wellbeing dimensions and finally into one single figure for the SSI using the un-weighted geometric average. More information about this index is available at: http://www.ssfindex.com/.

Proportional and absolute composite environmental (pENV and aENV) proposed by Bradshaw *et al*. (2010). These measurements make a ranking of 179 countries considering the biodiversity loss, deforestation and resource consumption in proportional or absolute terms, respectively.

Environmental Vulnerability Index (EVI) was developed by the South Pacific Applied Geoscience Commission (SOPAC) and the United Nations Environment Program. The EVI was designed to reflect the extent to which the natural environment of a country is prone to damage and degradation. Thus, it does not address vulnerability in social, cultural or economic terms, therefore neglecting the triple bottom line of sustainability (SOPAC, 2005). The EVI is based on 50 indicators (32 of hazards, 8 of resistance and 10 that measure damage (SOPAC, 2005)) and estimates the vulnerability of the environment of a country to future shocks. The EVI scale for normalisation ranges from a value of 1 (indicating high resilience/low vulnerability) and 7 (indicating low resilience/high vulnerability). The 50 indicators are combined in a single index obtained using an arithmetic mean with equal weights, a range of policy-relevant thematic sub-indices and as a profile showing the results for each indicator. The EVI takes the view of strong sustainability.

The link: http://www.vulnerabilityindex.net/EVI_2005.htm provides more detailed information about this index.

Well-Being of nations (WI). The Well-Being of nations is estimated for 180 countries by Prescott-Allen (2001). The WI is based on a Human Well-Being Index (HWI) and an Ecosystem Well-Being Index (EWI). These have five dimensions everyone and a total of 87 indicators are used to calculate WI. These dimensions include measurements of health, welfare, knowledge, culture, society, land, water, air, species and genes and a weighted arithmetic mean is used in the aggregation procedure to obtain the HWI and EWI indices in scale 0-100, respectivey (Prescott-Allen, 2001). Finally, the Well-Being of nations is the mean of the HWI and EWI, which give people and the ecosystem equal weight. The WI is a composite index that takes the viewpoint of weak sustainability. The HWI and EWI cover economic, environmental and social aspects of sustainability. However, the WI does not take leakage effects into consideration (Mayer, 2008) and therefore does not consider the triple bottom line of sustainability. More details about the WI are available at: http://pratclif.com/economy/wellbeing.htm or in Prescott-Allen (2001).

Human Development Index (HDI) was introduced in the first Human Development Report in 1990 and was created by economist Mahbubul Haq and published by the United Nations Development Programme. The first HDI covered 130 countries in 1990, 169 in 2010 and the last HDI released in 2012 covers 187 countries. The index has been calculated on an annual basis since 1990. The Human Development Index (HDI) is a composite development measure in three basic dimensions: a long and healthy life, knowledge and GDP per capita. The three base components of the HDI are: life expectancy at birth; adult literacy rate (with a weighting of two thirds) and the combined primary, secondary and tertiary gross enrolment ratio (with a weighting of one third); and GDP per capita (PPP US$). The indices are formulated on the basis of minimum and maximum values (goal posts) for each indicator and performance in each dimension is expressed as a value between 0 and 1. Originally, an arithmetic mean was used to obtain the HDI, but this methodology changed in 2010 to a geometric mean, which has been used ever since. The dimensions considered do not address environmental aspects and natural capitals at all. As a result, Mori and Christodoulou (2012) were unable to establish whether or not the HDI took the view of strong sustainability. More information about this index and the complete Human Development Reports can be consulted at: http://hdr.undp.org/en/humandev/.

Human Sustainable Development Index (HSDI). The HDI does not take into account the environment, so several studies have tried to build a "green HDI" (Costantini and Monni, 2005; Lasso de La Vega and Urutia, 2001; Blancard and Hoarau, 2011 and 2013). There are two main directions in the literature. Several authors calculate a kind of "green HDI" by incorporating ecological aspects directly into the construction of the index through per capita carbon emissions (Costantini and Monni, 2005; Garabedian and Hoarau, 2011; Hermele, 2006; Lasso De La Vega and Urutia, 2001; Nourry, 2008; Togtokh and Gaffney, 2010; Togtokh, 2011). Others consider human development and environmental sustainability separately, using the latter as a "threshold" variable indicating the potential level of current HDI sustainability (Moran *et al*., 2008; Morse, 2003; Neumayer, 2001 and 2010). In the first method, the SHDI obtained is computed in the same way as the HDI by UNDP, that is, using a weighted geometric average of its components, implying that the indicator is encompassed within the weak sustainability concept.

Table 1. Spearman's and the Kendall Tau rank correlation coefficients

	EF	EPI	GSI	SAFE	SSI	pENV	aENV	EVI	WI	HDI	HSDI
EF	**1**	0.585**	0.103	0.830**	0.234*	0.064	-0.025	0.166	0.733**	0.867**	0.835**
EPI	0.402**	**1**	0.093	0.700**	0.711**	-0.029	0.058	0.223*	0.747**	0.652**	0.686**
GSI	0.073	0.061	**1**	0.098	0.299**	-0.205	-0.053	0.196	0.090	0.105	0.114
SAFE	0.640**	0.505**	0.080	**1**	0.413**	0.108	0.156	0.209	0.770**	0.896**	0.895**
SSI	0.174*	0.523**	0.197**	0.291**	**1**	-0.183	0.036	0.275*	0.427**	0.340**	0.386**
pENV	0.054	-0.032	-0.141	0.077	-0.128	**1**	0.476**	-0.616**	0.127	-0.020	-0.048
aENV	-0.011	0.032	-0.032	0.118	0.014	0.311**	**1**	-0.217	0.092	-0.067	-0.036
EVI	0.122	0.150*	0.125	0.145	0.184*	-0.448**	-0.146	**1**	0.025	0.309**	0.346**
WI	0.546**	0.561**	0.068	0.578**	0.314**	0.082	0.061	0.023	**1**	0.758**	0.765**
HDI	0.689**	0.446**	0.082	0.706**	0.242	-0.020	-0.054	0.213	0.557**	**1**	0.990**
HSDI	0.641**	0.481**	0.082	0.706**	0.273**	-0.039	-0.037	0.236**	0.563**	0.939**	**1**

Source: Own elaboration. Note: the Spearman rho is shown above the diagonal and the Kendall tau below the diagonal. **p<0.01; *p<0.05

RESULTS & DISCUSSION

We have considered the rankings established using the: EF, EPI, GSI, SAFE, SSI, pENV, aENV, EVI, WI, HDI and HSDI indicators in order to analyse the correlation and concordance among the different rankings. As the number of countries considered in each ranking is different, we have selected those countries for which there is complete information for all the considered rankings. More specifically, we have 80 countries that have been ranked by each indicator considered. In order to analyse this concordance, we have used Spearman's (ρ) and the Kendall Tau (τ) rank correlation tests. These non-parametric measures of statistical dependence between two variables are measured as ordinal numeric and do not make any assumptions related to the distributions and allow to analyse the concordance between two rankings. The Kendall rank correlation test is calculated as:

$$\tau = \frac{n_c - n_d}{\frac{1}{2}n(n-1)}$$

where n_c is the number of concordances in the ranking, n_d the number of discordances and $\frac{1}{2}n(n-1)$ the total number of possible observation pairings. The following formula is used to calculate Spearman's rank correlation:

$$\rho = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

where d_i are the differences between the rankings of each observation on the two rankings analysed and n is the number of values in each data set.

Table 1 shows the coefficients calculated for each ranking. The results for both coefficients are similar, the values obtained with Spearman's rank correlation coefficient being higher.

The lowest degree of correlation (and even negative correlation) appears when measuring concordance in regard to the GSI, pENV and aENV. As a result, these indices record the most differences in regard to the rest. Therefore, we must take into account this situation when using these indicators because the results obtained using them should be different from the rest. The highest coefficients appear between the HDI and HSDI. These results are logical because the

HSDI is an adaptation of the HDI to take into account inequality and sustainability, respectively.

Therefore, all of the comments that appear in relation to the HDI can be extrapolated to the HSDI from this point onwards, although in this case the HSDI provides more interesting results because it includes sustainability in the HDI through the per capita carbon emissions in the case considered in this paper. The remainder of results show several aspects that have to be considered. First, the EF ranking has a higher concordance with the SAFE, WI and HDI rankings, the EPI ranking with SAFE, SSI, WI and HDI and the SAFE with WI and HDI. Second, the EVI ranking shows the least important relationships being only statistically significant at 1% with the HDI. Finally, the WI shows concordance with HDI, EF and EPI and the HDI rankings have little concordance with SSI and EVI. Therefore, several rankings record similar results despite using different methodologies, and could be used interchangeably to analyse the relationship between economic growth and environmental sustainability.

CONCLUSION

In this paper we have analysed several proposals to measure the sustainability of countries. More specifically, we have differenced two approaches, one based on country rankings and others developed for specific countries. Using the country rankings established by different indicators, we have analysed the concordance or discordance that exists between rankings. The results verify that some of the indicators establish similar rankings between countries and therefore could be used interchangeably to analyse the relationships between sustainability and economic growth. These results emphasise and clarify the discussion that exists in the specialised literature in relation to which indicator best analyses the relationship with economic growth and allow us to determine that EF, EPI, SAFE, WI and HSDI obtain similar results. The main two limitations of this paper appear as consequence of the data available. On one hand, the rankings obtained with different indicators are not for the same year and therefore the results can be different due to possible changes in the country rankings at the time. On the other hand, as the different indicators do not provide information for the same countries, we have been forced to remove some countries from the sample considered. This paper opens up several possible future research lines although the most interesting is the development of a sustainability measure that could be determined at city level, as cities should be the centre of future development.

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