EXTENDED ABSTRACT

Title: Quantitative techniques to measure the sustainability in European countries

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Abstract: *(minimum1500 words)*

Sustainability is commonly defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987). The 2030 Agenda for Sustainable Development is a United Nations program that represents a global commitment to achieving economic growth, social inclusion, and environmental sustainability in all countries. This Agenda is formed by several sustainable development goals and targets to converge on a new global policy framework to eradicate all forms of poverty, fight inequalities and confront climate change.

Sustainability is a multidimensional concept that usually is measured according to three basic dimensions of a region: social, economic, and environmental. Ideally, the best sustainability situation of territory would be attained when maximizing the benefits in the economic, social, and environmental dimensions, but there is a natural conflict among these three dimensions since when one is improved, some of the other need to be

sacrificed. This makes it clear the multiple criteria decision-making nature of sustainability.

Usually, sustainability is assessed using single indicators related to different aspects of the concept offering a global perspective. However, the best option is to obtain an indicator that aggregates the information of all single indicators related to the concept of sustainability. By definition, a composite indicator is the mathematical combination of single indicators that represent different dimensions of a concept whose description is the objective of the analysis (Saisana and Tanrantola, 2002).

In this work, 38 individual sustainability development indicators from 2010 to 2019 for the 27 European countries (Belgium, Bulgaria, Czechia, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, and Sweden) are considered. This information is available in the EUROSTAT database (https://ec.europa.eu/eurostat/web/sdi/main-tables). Considering the individual indicators related to the main goals of the Agenda 2030, three composite indicators are built related to economic, social and environmental dimensions.

Firstly, the composite economic indicator aggregates information about economic growth, employment, industry, innovation and infrastructure, economic inequalities, and consumption and production. On the other hand, the composite social indicator contains evidence of poverty, hunger, health, education, gender equality, water and sanitation, peace, justice and strong institutions. The last composite indicator, the environmental indicator, comprises the following aspect: clean energy, sustainable cities, climate action, life below water, and life on land.

The three composite indicators related to each of the dimensions are constructed using the Multiple Reference Point Weak and Strong Composite Indicators methodology (MRP-WSCI) proposed by Ruiz et al. (2020). This technique is based on the reference point preferential scheme. In this case, the reference levels used to build the composite indicators are the percentiles of 25, 50 and 75 of all induvial indicators across the European countries considered. The result of the composite indicator by country (of each dimension) can take values from 0 to 4. The interpretation of the result of each composite indicator by country is as follows:

- If the overall performance of the country is between the worst possible values and the percentile of 25, the value of the composite indicator will be between 0 to 1

- If the value of the composite indicator is between 1 to 2, the overall performance of the country is between the percentiles of 25 and 50.
- If the countries have an overall performance between the percentiles of 50 and 75, the value of the composite indicator will be between 2 and 3.
- If the value of the composite indicator is between 3 and 4, the overall performance of the country is between the percentile of 75 and the best possible values.

Three different approaches are considered to build the composite indicators: the Strong Composite Indicator (SCI), the Weak Composite Indicator (WCI) and the Mixed Composite Indicator (MCI). The first one reports information on the worse component of the indicator. The second one describes the position with respect to the global reservation and aspiration levels, and the last one is a mix of both two.

At this point, we have information by country (27 European countries) over 10 years regarding sustainability. For this reason, the data show particularities per country that cannot be ignored, so the following step, econometric analysis, is based on a fixed effect panel structure (Cameron and Trivedi, 2005). The Fixed Effects model deals with the unobserved heterogeneity by allowing the presence of correlation between the explanatory variables and time-invariant individual effects (measured by α), leaving an error term unit that is assumed to be independent of the regressors.

In this regression, the independent variables are the set of individual indicators that can be controlled by a policy maker. In total, fourteen independent or explanatory variables are considered in the econometric models. As explained or dependent variables are considered the three Mixed Composite Indicators built in the previous step related to the economic, social, and environmental dimensions.

Regarding the results of each model (economic, social and environmental). On the one hand, the economic composite indicator is explained by general government debt and circular material use. Also, this dimension of sustainability is explained by positions held by women in senior management which leads to a conflict between the social and economic dimensions. Secondly, the social composite indicator is described by the self-reported unmet need for a medical examination and care, the early leaver from education and training, and the positions held by women in senior management. Furthermore, is explained negatively by the environmental induvial indicator referred to as greenhouse emissions, indicating a conflict between the social and the environmental dimensions. Finally, the environmental composite indicator is explained by the greenhouse gas emissions, the recycling rate of municipal waste and the average CO2

emissions per km from new passenger cars. However, this dimension is not explained by individual indicators of economic and social dimensions.

Based on the result of the econometric analysis, and in order to get some insights into the impact that a modification of these controllable individual indicators would have on the overall sustainable development of the territories, an multiobjective optimization approach is considered.

Particularly, we focus on the Spanish case, whose sustainability situation can be improved, as this country does not reach the best possible values of the composite indicators of the three dimensions. However, to make a decision about how to improve its situation, further information is needed in order to know the extent of the possible improvement, the trade-offs existing among the dimensions, and how this improvement could be attained. Therefore, we build a multiobjective optimization problem based on the econometric analysis previously performed, which is aimed at identifying the most desired compromise among the three sustainability dimensions to enhance the sustainability situation of Spain. In this sense, the three econometric models (economic, social and environmental) are considered as objective functions of the multiobjective optimization problem. Also, we defined some technical constraints in order to make more realistic the problem. To solve the multiobjective optimization problem, preference-based multiobjective optimization techniques are used. Particularly, the algorithm used, called ERAL (González-Gallardo et al, 2021), is based on the achievement scalarizing function proposed by Wierzbicki (1980). This algorithm uses an aspiration point (values to be achieved) and a reservation point (values that cannot be worsened). The Pareto optimal front provided by ERAL is formed by non-dominated solutions between the aspiration and reservation points. In this sense, we can ensure that the solutions obtained fulfil the given preferences.

The problem is solved by ERAL taking into account different preference information to analyse the possible improvements that could be achieved under different scenarios.

The information provided by the results of the multi-objective problem can guide policy makers to design a set of policies that will lead to an improvement in the Spanish sustainability situation.

In addition, as a future line of research, we ask ourselves whether Spain could improve in order to reach the sustainability values of the best positioned countries in this aspect. On the other hand, it would be interesting to group the different countries according to their sustainability performance by clustering, and then try to reach a simultaneous

optimum of the three dimensions (economic, social and environmental) per country grouping.

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