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# Measuring the sustainability performances of the Italian regions

Tommaso Luzzati
*Department of Economics and Management, University of Pisa*
*E-mail: tommaso.luzzati@unipi.it*

Bruno Cheli
*Department of Economics and Management, University of Pisa*
*E-mail: bruno.cheli@unipi.it*

Sabrina Arcuri
*Department of Agriculture, Food and Environment, University of Pisa*

*Summary:* The aim of this paper is twofold, methodological and empirical. From the methodological point of view it aims at contributing to the debate about composite indicators, from the empirical one it assesses the relative sustainability of the Italian regions. Instead of building a single composite indicator (score) for each region, we calculate many composite indices by combining different weighting systems and rules of normalization and aggregation. In this way, we get a distribution function of the ranks (and a plausible rank range) for each country. Such an approach represents a good compromise between the need of synthesising the information provided by many variables and the need to avoid the loss of relevant information that occurs when several indicators are aggregated into a single composite index.

*Keywords:* Composite indicators; Rankings; Sustainability measurement.

## 1. Introduction

With the notion of sustainable development, the Brundtland report (WCDE 1987) asserted the importance of a healthy natural environment for the economy and the society. In principle, environmental goals have been given the same dignity of economic and social ones and the need of a compromise among these three spheres started to be affirmed. Since then, environmental policies have been implemented or invoked in the name of sustainability and our collective imaginary associates sustainability to natural environment protection. This is potentially harmful since we still tend to separate the environmental sphere from the economic one, with the consequence that we are tempted to care after the natural environment only when the economic conditions are good, that is, to accept the interpretation of the environmental quality as a luxury good. Why should we allocate resources to environmental quality in the presence of such a deep economic crisis?

The answer to this question comes actually from economics, since sustainability underpins one of the main economic notions, i.e., the notion of income. According to Hicks, for instance,

*the purpose of income calculations in practical affairs is to give people an indication of the amount which they can consume without impoverishing themselves. Remembering that the practical purpose of income is to serve as a guide for prudent conduct, I think it is fairly clear that this is what the central meaning must be. (Hicks, 1939, 172, Chapter. 14)*

Natural environment is a crucial asset, both for production and welfare. Hence, we should consider how much of it we can consume without impoverishing ourselves. Since, technically, GDP is merely an indicator of the size of the market and the public sector, our myopic focus on it induces us to classify as income what actually is depreciation of an important component of our capital, that is, the natural one. In other words, we cannot forget the strong links among the several spheres of sustainability, which has a general character and cannot further remain confined to the environmental dimension.

As emphasised by the institutionalist economist K.W. Kapp, preventing environmental degradation is a matter of sustainability since an unregulated competitive economy, via extra-market physical flows (i.e. externalities), threaten the economic process, its social reproduction, and hence the continued guarantee of human well-being and survival (Kapp 1976, p. 91; see also Kapp 1977, p. 205).

An operational definition of sustainability requires science to play a major role that is not limited to discover the technical trade-offs among different options but also to understand whether and how a given situation can be sustained over time. In other words, science has to indicate the domain within which society can choose, involving looking for absolute threshold values that should not be trespassed. Of course, the complexity of the real world makes such a task attainable at the cost of large uncertainties and a long time.

Sustainability, however, is not merely a technical problem, since, as Allen et al. (2002) highlighted, we need to choose what to sustain, for whom, how long, and at what price. To answer those questions, we need compromises among the conflicting goals of the different stakeholders (see, e.g., Munda 2005, 2009). Ethics is the third pillar of sustainability, limiting the field within which stakeholders can conflict.

As stated by Kapp, well in advance before the term sustainability became popular, the interplay of science, stakeholders and ethics is needed (see Luzzati 2009, 2010). In our view, this is crucial in making theoretically sound to assess sustainability in relative terms, by benchmarking, provided that the framework used to benchmark is widely accepted. Acceptance is an indication of an agreement among science, society, and ethics. Of course, stating that one country is more sustainable than another does not imply that it is sustainable, even if it ranks first. Benchmarking does not lift the burden of checking for absolute sustainability.

The empirical aim of this paper is comparing the sustainability of the Italian regions. The benchmarking framework we used is the Sustainable Development Strategy (SDS) of the EU adopted by the European Council in June 2006. SDS is an ambitious programme (reaffirmed and reviewed in 2009) aiming to continuously improve the quality of life and well-being for present and future generations, by linking economic development, protection of the environment and social justice (European Commission 2011, p. 11). Since measuring progress towards sustainability is an integral part of SDS, Eurostat has built a set of sustainable development indicators (SDIs) that, since 2007, are the basis for the EUROSTAT biennial monitoring report of the SDS. Hence the SDS provides a theoretical agreed framework and a wide reliable database.

The methodological aim of this paper is contributing to the debate about composite indicators within the issue of rank building. Rank building can be easily seen as the social choice problem of aggregating individual preferences into a social ordering. The debate on this issue dates back at least to the end of the 18th century, that is, to the Borda-Condorcet controversy (see e.g. Brian, 2008, Kemeny 1959). After Kenneth Arrows impossibility theorem, one can safely affirm that no method for establishing a complete order is perfect. Such impossibility is consistent with the everyday life difficulty that we experience when assessing alternatives, especially when they have a multifaceted nature.

At the same time, in order to evaluate (and choose), we need to synthesise the available information. For this reason composite indicators have become increasingly popular, both at the institutional level and in policy debate (see, e.g., Paruolo et al., 2013).

The methodological aim of this paper is to show that it is possible to use composite indicators without giving a too simplistic view of the phenomenon under inquiry. For this purpose, similarly to Saisana and Munda (2008), Floridi et al. (2011), Luzzati and Gucciardi (2013 and 2015), our approach hinges on sensitivity analysis. Instead of using a single composite index to build the ranking, we calculate many composites and the involved rankings. Hence we compute the frequency distribution of the different ranks displayed by each Region in order to infer a plausible rank range for it.

## 2. Methodology

*Indicators*

We used almost[1] the same indicators used by Luzzati and Gucciardi (2013) and

[1] The indicators were selected mainly in terms of their availability, both across time and at the regional level. Nonetheless, we had to slightly modify the original dataset due to changes in data availability. We also excluded a variable indicating the percentage of cars with standard euro 4 and 5. Actually it is not univocal the meaning of high levels in standards since they might simply tell that private car use is very high, involving

Floridi et al. (2011), that is, 65 variables grouped according to the themes of the Sustainable Development Strategy of the European Union. Their number in each of the eight[2] themes is as follows: 12 in Socio-economic development, 4 in Climate change and energy, 6 in Sustainable transports, 11 in Sustainable consumption and production, 4 in Natural resources, 10 in Public health, 15 in Social inclusion, 3 in Demographic change.

The correlation matrix showed high correlation among some indicators within the socio-economic domain, the social inclusion theme, and also across those two themes.[3] It has to be stressed, however, that redundancy involved by high correlation is not an issue here, since it merely can involve assigning more weight to an issue, which can be theoretically sound.[4]

As stated above, instead of building a single composite indicator, we moved directly to sensitivity analysis and built many composites by using different normalisation and aggregation rules.

*Normalization*

As a first step, inverse indicators, for which higher values involve poorer performance, have been linearly transformed into direct indicators according to the rule max+min - regional value, that is by assigning the highest value to the best region and the lowest to the worse. We could then normalise the indicators. To this purpose we used five different methods (Nardo et al., 2008), namely, Z-score, Borda count, Min-Max, Distance from the leader and Distance from the mean (See table 1).

*Aggregation*

We then aggregated the normalised indicators so as to obtain several composite indicators. To this purpose we used three different aggregation rules (see table 2), namely the arithmetic mean, the geometric mean and the concave mean.

The concave rule, suggested by Casadio et al., (2004), is a weighted arithmetic mean of a transformation of the normalized indicators.[5] This rule is a kind of compromise between the linear and the geometric aggregation since the lower the regional performances, the stronger the punishment for unbalanced performances, while as performances increase the aggregation becomes almost linear.

These different rules imply different degrees of compensability among indicators. Compensability is maximum under the linear (arithmetic) aggregation and minimum

a frequent car substitution rate. The indicators included in our analysis are available at http://dse.ec.unipi.it/l̃uzzati/documenti/indicators sustainability Luzzati.html

[2] Due to the scarcity of indicators with a clear theoretical relevance, the themes Global partnership and Good governance have been excluded.

[3] In particular .Occupation rate, Female occupation rate and Net income per capita showed very strong correlation ($|r| > 0.9$) among them and with some other variables.

[4] Nonetheless, we checked the consequences of excluding the three above mentioned variables getting no relevant differences in the results.

[5] Parameters k and h determine the concavity of the indicator transformation.

*Table 1. Normalization rules.*

| $Name$ | $Rule$ | $Range$ |
|---|---|---|
| Borda Count | $I_i{}^q = 1 - \frac{R_i{}^q - 1}{n}$ | (0;1] |
| Z-score | $I_i{}^q = \frac{x_i{}^q - \bar{x}^q}{\sigma^i}$ | 95% of the distribution $\in [-1; 1]$ |
| Min-max | $I_i{}^q = \frac{x_i{}^q - \min(x^q)}{\max(x^q) - \min(x^q)}$ | [0;1] |
| Distance from the leader | $I_i{}^q = \frac{x_c{}^q}{\max(x^q)}$ | [0;1] |
| Distance from the average | $I_i{}^q = \frac{x_i{}^q}{\bar{x}^q}$ | $> 0$ |

where

$I_i{}^q$ is the normalised indicator for variable q and Region i, R is the rank, $\bar{x}$ the average, $\sigma$ the standard deviation, min and max respectively the minimum and the maximum value, of the indicator q across Regions.

*Table 2. Aggregation rules.*

| $Name$ | $Rule$ |
|---|---|
| Linear (arithmetic): | $CI_i = \sum_{q=1}{}^Q w^q I_i{}^q$ |
| Geometric | $CI_i = \prod_{q=1}{}^Q (I_i{}^q)^{w_q}$ |
| Concave | $CI_i = \sum_{q=1}{}^Q w_q(I_i{}^q - h\exp(-kI_i{}^q)$ |

under the geometric one, whereas by using the concave mean the degree of compensability gets higher as the performance improves.

*Weighting*

Aggregation requires a weighting system. Since sustainable development should result from a balance of all the considered dimensions, we gave equal weight to each macro-theme (EWT) and weighted the indicators accordingly. In particular, any indicator in the i-th macro-theme (i=1, , 8) was given a weight equal to $1/n_i$, where $n_i$ represents the number of indicators belonging to the i-th theme.

Since some aggregation rules cannot be used with some normalization rules[6] , by combining normalization and aggregation rules we ended up with 11 different composite indicators, which we refer to as basic EWT(see also column B of table 3).

An important topic in weighting is that poor performances in some indicators could arise because they involve issues that are not among the goals of the regional policy or because of some peculiarities (i.e. geographical and historical features) that cannot be easily modified. The benefit-of-the doubt (BOD) approach (see Melyn and Moesen, 1991) takes this into account. In our work we used a similar, but algorithmically simpler, scheme. We built 20 optimistic weighting systems by iteratively excluding for each of the 20 regions its worst 6 indicators. Thus, we ended up with 21 weighting systems, the basic EWT and the 20 optimistic ones.

*Sensitivity analysis*

Having many possible indicators, we ran five experiments for which we calculated the frequency distribution of the ranks of each region and its median value. In the first experiment we included only the 11 basic EWT composites. This experiment is labelled as B. The other experiments included all the 21 weighting systems. Experiments L, G and C used respectively the linear, the geometric and the concave aggregation rules. This allows us to explore the effects of reducing the compensability among indicators. Finally, experiment A used all possible rankings. Table 3 describes the experiments we ran.

## *3. Results*

For the sake of synthesis, we show here only the frequency distribution of the ranks for each region resulting from the two polar cases, experiments B and A (Table 4 and 5). Each cell reports the rounded percentage frequency of each rank; the darker the colour the higher the frequency. Regions are ordered according to the median values, indicated on the right of their names. For instance, in table 4 Piemonte ranks 3rd in 27% of the rankings, 9th in 9%, 5th in 18% and so on, while its median rank is 5.

As expected, the higher the number of indicators, the higher the dispersion of each frequency distribution. For instance, Umbria ranges from the 11th to the 14th position

[6] For instance, the geometric aggregation cannot be used when normalization involves zero values, as in the case of min-max rule.

*Table 3. Number of composite indicators for each experiment*

| *Aggregation* | *Normalization* | B Basic | L Linerar | G Geom. | C Conc. | A All |
|---|---|---|---|---|---|---|
| Linear | Z-Score | 1 | 21 | | | 21 |
| | Min-Max | 1 | 21 | | | 21 |
| | Borda Count | 1 | 21 | | | 21 |
| | Dist.from leader | 1 | 21 | | | 21 |
| | Dist. from average | 1 | 21 | | | 21 |
| Geometric | Borda Count | 1 | | 21 | | 21 |
| | Dist.from leader | 1 | | 21 | | 21 |
| | Dist. from average | 1 | | 21 | | 21 |
| Concave Mean | Z-Score | 1 | | | 21 | 21 |
| | Min-Max | 1 | | | 21 | 21 |
| | Dist from leader | 1 | | | 21 | 21 |
| ***Total Composite Indicators*** | | ***11*** | ***105*** | ***63*** | ***63*** | ***231*** |

if indicators are 11 and ranges from the 2nd to the 17th if indicators are 231. However, the median ranks do not change much.

Table 6, then, reports the median ranks obtained by each region in each of the five experiments and the involved rank range. By comparing columns L, C and G we can see the effects of different compensability among indicators involved by the different aggregation methods, as mentioned above. For instance, for regions whose performances are highly variable across themes, e.g. Valle d'Aosta and Lombardia (see table 7), linear aggregation gives better rankings than the concave and the geometric ones (see dotted and highlighted cells in Table 6).

The issue is now to synthesise the results of this analysis and to draw some conclusions. Since no perfect method to build rankings exists and any method is intrinsically arbitrary, what we suggest here is focusing on the range of the median rankings. This is reported in bold in table 6, at the 7th column, in grey. In our opinion, the range is what should be communicated, in a first instance, to the general public a politicians. This is the first step to communicate the intrinsic uncertainty of the rank.

Of course, a ranking is needed if one wants to compare our results with the rankings based on other indicators. In order to do so, we needed to provide an actual ranking, that is, to choose a further aggregation rule for combining the results of the different experiments. The ranking we propose is reported in the column in italic, labelled "sust rank", which is obtained by ranking regions according to their average[7] median. The same ranking is obtained, in this case, by pairwise comparison (Condorcet-like) of the medians.

The last two columns of Table 6 report the comparison of our ranking with the regional rankings based respectively on GDP p.c. and the Gini index. A glance at the figures in the Table 6 shows that a positive correlation between our sustainability rank-

[7] In this case, the arithmetic and geometric means give the same ranking.

Table 4. Frequency distribution (%) of ranks and median of experiment "Basic"

| *Region* | *M* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trent. A.A. | 1 | 91 | | 9 | | | | | | | | | | | | | | | | | | 100 |
| Toscana | 2 | | 55 | 18 | 9 | 18 | | | | | | | | | | | | | | | | 100 |
| Lazio | 3 | 9 | 27 | 18 | 18 | 18 | 9 | | | | | | | | | | | | | | | 100 |
| Liguria | 4 | | 9 | 9 | 36 | 9 | 9 | 18 | | 9 | | | | | | | | | | | | 100 |
| V. d'Aosta | 5 | | 9 | 18 | 18 | 9 | 18 | | 18 | | | | | | | | | 9 | | | | 100 |
| Piemonte | 5 | | | 27 | 9 | 18 | 36 | 9 | | | | | | | | | | | | | | 100 |
| Marche | 7 | | | | 9 | 18 | | 27 | 27 | 9 | | 9 | | | | | | | | | | 100 |
| Abruzzo | 7 | | | | | | 27 | 27 | 9 | 9 | 27 | | | | | | | | | | | 100 |
| Emilia Rom | 9 | | | | | | | 9 | 9 | 45 | 36 | | | | | | | | | | | 100 |
| Friuli V G | 10 | | | | | | | | 9 | 27 | 27 | 18 | 9 | | 9 | | | | | | | 100 |
| Lombardia | 11 | | | | | 9 | | 9 | 27 | | | 18 | 9 | 9 | | 18 | | | | | | 100 |
| Umbria | 12 | | | | | | | | | | | 45 | 9 | 27 | 18 | | | | | | | 100 |
| Veneto | 13 | | | | | | | | | | 9 | | 36 | 36 | 9 | 9 | | | | | | 100 |
| Sardegna | 15 | | | | | | | | | | | | 9 | | 36 | 27 | 18 | | 9 | | | 100 |
| Molise | 15 | | | | | | | | | | | | | 18 | 18 | 27 | 9 | 27 | | | | 100 |
| Campania | 15 | | | | | | | | | | | | 27 | 9 | 9 | 9 | 18 | 27 | | | | 100 |
| Calabria | 17 | | | | | | | | | | | 9 | | | | | 27 | 18 | 45 | | | 100 |
| Basilicata | 17 | | | | | | | | | | | | | | | 9 | 27 | 18 | 36 | | 9 | 100 |
| Sicilia | 19 | | | | | | | | | | | | | | | | | | 9 | 82 | 9 | 100 |
| Puglia | 20 | | | | | | | | | | | | | | | | | | | 18 | 82 | 100 |

Table 5. Frequency distribution (%) of ranks and median of experiment "All"

| *Region* | *M* | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trent.A.A. | 1 | 76 | 11 | 4 | 2 | 3 | 3 | 1 | | | | | | | | | | | | | | 100 |
| Toscana | 3 | 5 | 32 | 31 | 20 | 10 | | | | | | | | | | | | | | | | 100 |
| Lazio | 3 | 9 | 30 | 18 | 15 | 15 | 6 | 3 | | 1 | 1 | 1 | 1 | | | | | | | | | 100 |
| Liguria | 5 | 3 | 6 | 17 | 24 | 17 | 9 | 8 | 5 | 2 | 4 | 2 | 1 | 1 | | | 1 | | | | | 100 |
| Piemonte | 5 | 1 | 5 | 21 | 18 | 19 | 22 | 11 | 2 | 1 | | | | | | | | | | | | 100 |
| V. d'Aosta | 7 | 5 | 12 | 4 | 9 | 7 | 6 | 11 | 7 | 8 | 5 | 10 | 5 | 2 | | | | 3 | 3 | 2 | | 100 |
| Abruzzo | 7 | | 1 | 2 | 3 | 6 | 23 | 16 | 11 | 11 | 17 | 6 | 2 | 1 | | | | | | | | 100 |
| Marche | 8 | 1 | 1 | 2 | 5 | 9 | 13 | 16 | 23 | 13 | 7 | 6 | 3 | 1 | | | | | | | | 100 |
| Emilia Rom | 9 | | | | | 2 | 5 | 11 | 22 | 26 | 19 | 10 | 1 | 1 | 1 | | | | | | | 100 |
| Lombardia | 9 | | 1 | 2 | 3 | 7 | 10 | 10 | 10 | 8 | 10 | 7 | 8 | 6 | 3 | 9 | 3 | 1 | 1 | | | 100 |
| Friuli V G. | 10 | | | | | 2 | 2 | 8 | 13 | 23 | 15 | 16 | 9 | 5 | 2 | 2 | | 2 | | | | 100 |
| Veneto | 12 | | | | | | | 1 | | 3 | 8 | 11 | 28 | 23 | 14 | 5 | 1 | 2 | 2 | | | 100 |
| Umbria | 13 | | 1 | | | 2 | | 1 | 2 | 1 | 9 | 15 | 18 | 25 | 16 | 4 | 3 | 2 | | | | 100 |
| Campania | 14 | | | | | | | 1 | 2 | 1 | 3 | 8 | 11 | 13 | 20 | 7 | 18 | 12 | 4 | | | 100 |
| Sardegna | 15 | | | | | | | 1 | | | | 2 | 2 | 10 | 19 | 33 | 20 | 7 | 4 | | | 100 |
| Molise | 15 | | | | | | | | 1 | | | 1 | 6 | 5 | 18 | 20 | 23 | 16 | 9 | | | 100 |
| Basilicata | 17 | | | | | | | | | | | | 1 | 3 | 4 | 8 | 16 | 29 | 26 | 3 | 7 | 100 |
| Calabria | 17 | | | | | | | | 1 | | 1 | 3 | 3 | 2 | 3 | 11 | 12 | 23 | 32 | 8 | 1 | 100 |
| Sicilia | 19 | | | | | | | | | | | | | | | | | 3 | 16 | 68 | 13 | 100 |
| Puglia | 20 | | | | | | | | | | | | | | | | | 1 | 2 | 18 | 79 | 100 |

| Region | Median B | L | C | G | A | Rank. Range | *sust rank* | GDP p.c. | Gini |
|---|---|---|---|---|---|---|---|---|---|
| Trentino A.A. | 1 | 1 | 1 | 1 | 1 | 1 | ***1*** | 2 | 4 |
| Toscana | 2 | 4 | 2 | 2 | 3 | 2-4 | ***2*** | 8 | 9 |
| Lazio | 3 | 2 | 3 | 5 | 3 | 2-5 | ***3*** | 6 | 17 |
| Piemonte | 5 | 6 | 4 | 3 | 5 | 3-6 | ***4*** | 9 | 14 |
| Liguria | 4 | 4 | 6 | 5 | 5 | 4-6 | ***5*** | 10 | 10 |
| Valle d'Aosta | 5 | 4 | 10 | 8 | 7 | 4-10 | ***6*** | 13 | 1 |
| Abruzzo | 7 | 9 | 6 | 7 | 7 | 6-9 | ***7*** | 11 | 7 |
| Marche | 7 | 9 | 6 | 7 | 8 | 6-9 | ***8*** | 1 | 6 |
| Emilia Romagna | 9 | 8 | 9 | 10 | 9 | 8-10 | ***9*** | 4 | 8 |
| Friuli V Giulia | 10 | 11 | 9 | 9 | 10 | 9-11 | ***10*** | 7 | 5 |
| Lombardia | 11 | 8 | 12 | 13 | 9 | 8-13 | ***11*** | 3 | 11 |
| Umbria | 12 | 13 | 13 | 11 | 13 | 11-13 | ***12*** | 5 | 2 |
| Veneto | 13 | 13 | 12 | 13 | 12 | 12-13 | ***13*** | 12 | 3 |
| Campania | 15 | 14 | 14 | 17 | 14 | 14-17 | ***14*** | 20 | 18 |
| Sardegna | 15 | 16 | 15 | 14 | 15 | 14-16 | ***15*** | 15 | 12 |
| Molise | 15 | 16 | 15 | 14 | 15 | 14-16 | ***15*** | 14 | 13 |
| Basilicata | 17 | 18 | 17 | 16 | 17 | 16-18 | ***17*** | 16 | 19 |
| Calabria | 17 | 16 | 18 | 18 | 17 | 16-18 | ***18*** | 19 | 15 |
| Sicilia | 19 | 19 | 19 | 19 | 19 | 19 | ***19*** | 18 | 20 |
| Puglia | 20 | 20 | 20 | 20 | 20 | 20 | ***20*** | 17 | 16 |

Table 6. Median ranks, plausible ranking ranges, and comparison with per capita GDP and Gini index

ing and each one of the other two rankings exists, but it is far from being very strong. This impression is confirmed by the Spearmans rank correlation coefficients that are respectively 0.71 and 0.47.

In order to make our analysis more complete, we did several further checks investigations. In particular, we compared our results with the ones that one would get by using single composites. We found that none of the eleven basic EWT composites gives the same ranking as our sustainability ranking. This means that no single composite is able to reproduce our sustainability ranking. Table 7 compares our rank range with two popular composite, built by linearly aggregating indicators that have been normalized respectively by the Z-score and the distance from the leader rules. Moreover, the last column of the table displays the ranking obtained by combining the distance from the leader normalization rule with the concave mean aggregation. Such a ranking comes out to be the closest to our ranking in terms of sum of squared deviation. Next to each ranking, emoticons and thick help visualising whether the ranking produced by a single composite falls within, above, or below our range.

The general public and the policy-makers should now be made aware of the reasons behind the ranking. This requires zooming in, that is, exploring the performance of each regions in each theme. To the purpose of this paper, it is enough to highlight that each region, even those in the top part of the ranking, has mixed performances across

| Region | Our ranking | Z-score & Linear | | Dist. from leader & Linear | | Dist. from leader & Concave | |
|---|---|---|---|---|---|---|---|
| Trentino A.A. | 1 | 1 | ✓ | 1 | ✓ | 1 | ✓ |
| Toscana | 2-4 | 5 | ☹ | 4 | ✓ | 2 | ✓ |
| Lazio | 2-5 | 2 | ✓ | 3 | ✓ | 6 | ☹ |
| Piemonte | 3-6 | 6 | ✓ | 6 | ✓ | 5 | ✓ |
| Liguria | 4-6 | 4 | ✓ | 2 | ☺☺ | 3 | ☺ |
| Valle d'Aosta | 4-10 | 3 | ☺ | 5 | ✓ | 4 | ✓ |
| Abruzzo | 6-9 | 9 | ✓ | 8 | ✓ | 7 | ✓ |
| Marche | 6-9 | 7 | ✓ | 7 | ✓ | 8 | ✓ |
| Emilia Romagna | 8-10 | 10 | ✓ | 9 | ✓ | 9 | ✓ |
| Friuli V Giulia | 9-11 | 11 | ✓ | 10 | ✓ | 10 | ✓ |
| Lombardia | 8-13 | 8 | ✓ | 11 | ✓ | 12 | ✓ |
| Umbria | 11-13 | 14 | ☹ | 13 | ✓ | 11 | ✓ |
| Veneto | 12-13 | 13 | ✓ | 14 | ☹ | 13 | ✓ |
| Campania | 14-17 | 12 | ☺☺ | 12 | ☺☺ | 16 | ✓ |
| Sardegna | 14-16 | 15 | ✓ | 16 | ✓ | 15 | ✓ |
| Molise | 14-16 | 17 | ☹ | 15 | ✓ | 14 | ✓ |
| Basilicata | 16-18 | 18 | ☹ | 18 | ☹ | 17 | ✓ |
| Calabria | 16-18 | 16 | ✓ | 17 | ✓ | 18 | ✓ |
| Sicilia | 19 | 19 | ✓ | 19 | ✓ | 19 | ✓ |
| Puglia | 20 | 20 | ✓ | 20 | ✓ | 20 | ✓ |

Table 7. A comparison between our ranges and ranking of single composite

themes. This is shown by Table 8, which reports the rankings in each theme for each Region. Since our purpose is just to show the variability of individual performances across themes, we report here only the rankings obtained by combining the distance from the leader normalisation and concave aggregation rules, which, as we said above, produces the closest results to our ranking. As mentioned before, we can see that the variability across themes of some regions are much higher than others.

## 4. *Concluding remarks*

The approach followed here is intended to be a compromise between the need of synthesis when considering many variables and the loss of relevant information occurring when many indicators are aggregated into a single composite measure. An issue with composite indicators is related to their strong communicative power that can be disproportionate as compared to their reliability, which is generally low, since such indices (and the resulting rankings) are strongly affected both by the choice of the component indicators and by the method to construct them.

For this reason, we did not build a single composite and we started directly from sensitivity analysis. In conclusion, we believe that the resulting interval of plausible ranks of any Region is able to communicate the uncertainty involved in the assessment

| | Socio-Econ devel. | Climate Ch. & Energy | Transp. | Cons. & Prod. | Natural resourc es | Public health | Soc. Inclus. | Demogr . change |
|---|---|---|---|---|---|---|---|---|
| Abruzzo | 12 | 7 | 11 | 3 | 5 | 15 | 13 | 9 |
| Basilicata | 16 | 3 | 14 | 7 | 13 | 11 | 16 | 18 |
| Calabria | 20 | 1 | 6 | 9 | 15 | 12 | 17 | 20 |
| Campania | 14 | 5 | 2 | 2 | 7 | 20 | 20 | 17 |
| Emilia-Rom. | 1 | 19 | 19 | 10 | 14 | 9 | 2 | 3 |
| Friuli V. G. | 3 | 17 | 12 | 14 | 10 | 16 | 3 | 10 |
| Lazio | 9 | 10 | 3 | 12 | 16 | 5 | 11 | 1 |
| Liguria | 8 | 16 | 1 | 18 | 1 | 14 | 9 | 12 |
| Lombardia | 2 | 15 | 20 | 16 | 20 | 2 | 5 | 4 |
| Marche | 10 | 12 | 15 | 4 | 12 | 8 | 8 | 13 |
| Molise | 19 | 6 | 4 | 20 | 3 | 4 | 14 | 14 |
| Piemonte | 4 | 11 | 10 | 5 | 11 | 10 | 6 | 7 |
| Puglia | 17 | 18 | 5 | 17 | 19 | 13 | 18 | 19 |
| Sardegna | 15 | 14 | 9 | 11 | 6 | 6 | 15 | 15 |
| Sicilia | 18 | 9 | 8 | 19 | 18 | 18 | 19 | 16 |
| Toscana | 7 | 8 | 16 | 6 | 4 | 7 | 4 | 5 |
| Trentino A. A. | 6 | 2 | 7 | 1 | 9 | 17 | 1 | 2 |
| Umbria | 11 | 20 | 13 | 13 | 8 | 3 | 10 | 8 |
| V. d'Aosta | 13 | 4 | 17 | 8 | 2 | 1 | 12 | 6 |
| Veneto | 5 | 13 | 18 | 15 | 17 | 19 | 7 | 11 |

Table 8. Rankings across themes (according to “Dist. from leader & Concave” composite)

of multifaceted phenomena. Moreover, a robustness approach, by strongly reducing the impact of any single indicator, also mitigates the problem of choosing the appropriate indicators for building the composite.

Finally, it has to be emphasised that the exercise presented in this paper should not be regarded as an amusing divertissement but as a basis and stimulus for regional analysis and policies.

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