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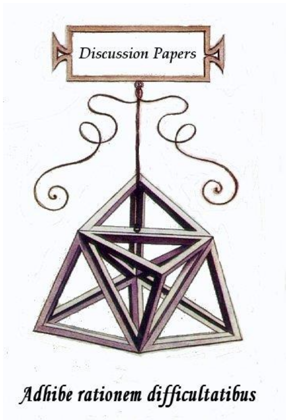

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Measuring the sustainability performances of the Italian regions

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Abstract
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.

Il lavoro ha un duplice scopo, metodologico e empirico. Esso intende contribuire sia al dibattito sull'uso degli indicatori compositi, sia a valutare la sostenibilità relativa delle regioni italiane, indagandone anche l'eventuale legame con la diseguaglianza. Anzichè costruire un indicatore composito per ciascuna regione, ne costruiamo molti usando differenti regole di normalizzazione, aggregazione e diversi sistemi di pesi. Otteniamo così una distribuzione di frequenza dei ranghi delle regioni e dunque un piazzamento plausibile per ciascuna di esse. Un simile approccio appare come un buon compromesso tra la necessità di sintesi in presenza di molti indicatori e quella di evitare la perdita di informazione che deriva dall'aggregazione di molti indicatori in un singolo indice composito.

Classificazione JEL: D63, E01, Q01
Keywords: composite indicators; rankings; sustainability.

1. Introduction

Sustainability is a key goal of the European Union. An ambitious and comprehensive renewed Sustainable Development Strategy (SDS) was adopted in June 2006 and reviewed in 2009 (European Commission 2011). The issue of rank building can be easily seen as the social choice problem of aggregating individual preferences into a social ordering. The debate on this theme dates back at least to the end of the 18th century, that is, to the Borda-Condorcet controversy (see e.g. Brian, 2008). After Kenneth Arrow's 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. Thus, 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), our approach hinges on sensitivity analysis. Instead of building a single composite index and rely on it, we calculate many composites with their related 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

We considered the same indicators used by Luzzati and Gucciardi (2013) and Floridi et al. (2011)[1], grouped according to the themes[2] of the Sustainable Development Strategy of the European Union[3] . Our 65 variables are

[1]The indicators in the original database 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 a frequent car substitution rate. The indicators included in our analysis are available on http://dse.ec.unipi.it/~luzzati/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]The correlation matrix showed high correlation among some indicators within the socioeconomic domain, the social inclusion theme, and also across those two themes. 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.

It has to be stressed, however, that redundancy involved by high correlation is not an issue here, since it simply involves assigning more weight to an issue, which can be theoretically sound. Nonetheless, we checked the consequences of excluding the three above mentioned variables getting no relevant differences in the results.

distributed among eight themes 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’.

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

We normalised our indicators[4] according to five different methods (Nardo et al., 2008), namely, Z-score, Borda count, ‘Min-Max’, ‘Distance from the leader’ and ‘Distance from the mean’.

Then, in a first step, we aggregated the normalised indicators belonging to each of the eight themes so as to obtain a composite index for that theme. In a second step we aggregated the eight composite indices derived in this way in order to obtain global index of sustainability. In this procedure we used three different aggregation rules, namely the arithmetic mean, the geometric mean and the ‘concave mean’ (see Casadio et al., 2004)[5] . These methods imply different degrees of compensability among indicators. Compensability is maximum under the linear (arithmetic) aggregation and minimum under the geometric one, whereas by using the concave mean the degree of compensability gets higher as the sustainability performance improves.

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 indicators accordingly. In particular, any indicator in the i-th macro-theme (i=1, …, 8) was given a weight equal to 1/ni, where ni represents the number of indicators belonging to the i-th theme.

In weighting, sn important topic is that poor performances in some indicators could arise because they involve issues which are not among the goals of the regional policy or because of some peculiarities (i.e. geographically/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

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[4] The inverse indicators, for which higher values are negatively assessed, have been linearly transformed into direct indicators according to the rule ‘max+min-regional value’.

[5] This rule is a kind of compromise between the linear and the geometric aggregation for which the lower the country performances, the stronger the ‘punishment’ for unbalanced performances, while as performances increase the aggregation becomes almost linear. More specifically, this rule is a weighted aggregated arithmetic average of a transformation of the normalized indicators

$$CI_c = \sum_{q=1}^{Q} w_q (I_c^q - he^{-kI_c^q})$$

where *CIc* is the composite indicator for region *c*, *q* is the index of summation for the *Q* variables, *w* is the weight, *I* is the normalised indicator, *k* and *h* are parameters determining the concavity of the indicator transformation.

regions its worst 6 indicators. Thus, we ended up with 11 different indicators[6] and 21 weighting systems.
We then run five "experiments", for which we calculated the frequency distribution of the ranks for each country and the median value. "Experiment" A included the 11 basic composites. The other experiments included also the 20 'optimistic' weighting systems. "Experiments" B, C and D used the three different aggregation rules to explore the effects of reducing the compensability among indicators[7]. Finally, "experiment" E used all possible rankings, i.e., 231.

3. *Results*

Due to space limits, we show here only the frequency distribution of the ranks for each region resulting from "experiment" E (Table 1). Each cell reports the relative frequency of each rank; the darker the colour the higher the frequency. Regions are ordered according to the median values, indicated besides the name of each region. For instance, Toscana ranks first with 5% frequency, 2nd with 32%, 3rd with 31% and so on, while its median rank is 3.

Table 1: Frequency distribution of ranks resulting from "experiment" E, 231 rankings (per cent values).

231 rankings	Median	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Trentino	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
Valle 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 Romagna	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 Giulia	10					2	2	8	13	23	15	16	9	5	2	2		2				100
Veneto	12							1		3	8	11	28	23	14	5	3	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

[6] Notice that some aggregation schemes cannot be used with some normalization rules. For instance, geometric aggregation cannot be used when normalization involves zero values, as in the case of min-max rule.
[7] The experiments involved respectively 105, 63, and 63 rankings.

Table 2 reports the median ranks obtained by each region in each of the five "experiments" and the involved rank range. The order with which regions are listed in the table can be obtained using with several criteria[8]. By comparing columns B, C and D we can see the effect of different compensability among indicators involved by different aggregation methods, as explained in the previous section. For instance, for regions whose performances are highly variable, e.g. Valle D'Aosta and Lombardia, linear aggregation gives better rankings than the concave and the geometric ones.
The last three columns report respectively our sustainability ranking and the rankings based respectively on GDP p.c. and on Gini index. It is evident that the correlation with our sustainability ranking is far from being perfect. Spearman's rank correlation coefficients are respectively 0.71 and 0.47.

Table 2: Median ranks, plausible ranking ranges and relation with per capita GDP and Gini index

Region	**Median**					**Rank. Range**	*sust rank*	**GDP p.c.**	**Gini**
	A	**B**	**C**	**D**	**E**				
Trentino	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
Abruzzo	6	4	10	8	7	4-10	*6*	13	1
Marche	7	9	6	7	7	6-9	*7*	11	7
Valle d'Aosta	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
Veneto	13	13	13	11	13	11-13	*12*	5	2
Umbria	13	13	12	13	12	12-13	*13*	12	3
Campania	14	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	*17*	19	15
Sicilia	19	19	19	19	19	19	*19*	18	20
Puglia	20	20	20	20	20	20	*20*	17	16

We then did several checks and further investigations, availabe upon request. In particular, we found that none of the eleven simple composites give the same ranking as ours. We also attempted to understand the reasons for our ranking by calculating the thematic performances of each region. A general result is that each region, even those in the top part of the ranking, has mixed performances across themes.

[8] Both the arithmetic and the geometric average of the medians involves the region order shown in the table. The same order can be obtained by pairwise comparison of the medians.We have two ties, on Molise and Sardegna, the other between Basilicata and Calabria.

3. 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. A big 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 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 for regional analysis and policies.

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