Composite Index for Measuring Italian Regions' Environmental Quality Over Time

Carlo Lucarelli[1], Matteo Mazziotta[2], Valentina Talucci[3] and Paola Ungaro[4]

[1] *Istat; calucare@istat.it*
[2] *Istat; mazziott@istat.it*
[3] *Istat; talucci@istat.it*
[4] *Istat; ungaro@istat.it*

Abstract. *Many socio-economic phenomena have a multidimensional nature and require the definition of a set of individual indicators in order to be properly assessed. The application of a specific statistical technique, called composite index, allows to synthesize the phenomenon making it one-dimensional. One of the main problems in constructing composite indices is the choice of a method that enables to assess changes over time. According to this target, in the paper, we apply a variant of the Mazziotta-Pareto Index (MPI) which allows spatial and time comparisons across units to be made. An application to a set of individual indicators of environmental quality in Italian regions is presented and the reference years are 2006 and 2011. According to the selected indicators, the results show, for a five-year period, an improving trend of environmental quality in all Italian regions.*

Keywords. *Social Indicators; Environmental Quality; Composite Index.*

1 Introduction

Environmental quality is the core of the most recent International political plans (eg. Europe 2020) and it depends both on the growth of economic sustainability and on social development of a country. It is a typical multidimensional phenomenon, not only for the multiplicity of environmental aspects that define it, but also because strictly linked to economic and social domains. Environmental quality needs to be analyzed by a multidisciplinary approach and measured by many components which describe the conditions of the environment referring, among others, to: physical conditions, soil and land cover, biodiversity and ecosystems, air quality, water quality, energy resources, waste (UN, 2013). From a subjective point of view, also opinions, behaviors and perceptions of population play a relevant role, given the close relationship between environmental quality, quality of life and individual and social well-being. The aim of the paper is both proposing an innovative composite index and testing it to the changes in environmental quality in the period 2006-2011 for Italian regions, according to a selection of

six individual indicators which represent some of the conceptual dimensions above described.

2 The adjusted MPI

The Mazziotta-Pareto Index (MPI) is a non-compensatory composite index based on a standardization of the individual indicators, at the reference time, that makes the indicators independent of the variability (normalized indicators have a mean of 100 and a standard deviation of 10) [1].Therefore, all the individual indicators are assigned equal weights, but only relative time comparisons are allowed.In order to perform absolute comparison over time, we propose a re-scaling of the individual indicators in the range (70; 130) according to two goalposts, i.e., a minimum and a maximum value which represent the possible range of each variable for all time periods and for all units. The steps for computing the adjusted MPI are given below [2]. Given the matrix $X = \{x_{ij}\}$ with n rows (units) and m columns (indicators), we calculate the normalized matrix $R = \{r_{ij}\}$ as follow:

$$r_{ij} = \frac{x_{ij} - Min_{x_j}}{Max_{x_j} - Min_{x_j}} 60 + 70$$

where x_{ij} is the value of the indicator j for the unit i and Min_{x_j} and Max_{x_j} are the goalposts for the indicator j. If the indicator j has negative polarity, the complement to the formula below with respect to 200 is computed. Denoting with M_{r_i} and S_{r_i}, respectively, the mean and the standard deviation of the normalized values of the unit i, the generalized form of the adjusted MPI is given by:

$$MPI_i = M_{r_i} \pm S_{r_i} CV_i$$

where $CV_i = \frac{S_{r_i}}{M_{r_i}}$ is the coefficient of variation of the unit i and the sign $\pm$ depends on the kind of the phenomenon to be measured. In order to facilitate interpretation of results, we suggest to choose the goalposts so that 100 represents a reference value (e.g., the average in a given year).

3 An application to real data

The individual indicators used for the synthesis are provided in the system of indicators "Noi Italia" (noi-italia.istat.it) and partly from the environment domain project BES (Equitable and Sustainable Well-Being, www.misuredelbenessere.it) The criteria for selecting individual indicators are two: 1) conceptual: representativeness of dimensions; 2) empirical: availability of regional data for the same years. The dimensions and the individual indicators are the following. Biodiversity protection (ind1, with + polarity): Areas of special naturalistic interest (source MATTM). It gives an indication of areas of high natural value that contribute to the quality and value of natural ecosystems. Waste (ind2, +): Separate waste collection per region (source Ispra). It responds to a specific legal requirement regulated in Italy since 2006 (Law 296/2006). Air (ind3, -): Emissions of CO2 and other greenhouse gasses (source Ispra). This information meets indications contained Kyoto Protocol to reduce emissions of greenhouse gases that are the main cause of global warming. Population perceptions and evaluations (ind4, - and ind5, +): Households that declare very or quite present issues related to air quality in the area in which they live and Individuals who declare themselves very or quite satisfied with the state of the environment (air, water, noise, etc.) of the area in which they reside (source Istat). The relationship between population and environment contribute to the definition of the level of environmental consciousness of the population. Energy resources (ind6 , +): Electricity generated from renewable sources (source Terna).

The development of renewable energy sources is a priority for all Member States (European strategy 2020). In this application the adjusted MPI with negative algebra sign is applied because the polarity of the phenomenon is positive. The method is constructed fixing the value of Italy (2006) equal to 100 in order to make comparisons with the year 2011.

Region	Ind.1 2006	Ind.2 2006	Ind.3 2006	Ind.4 2006	Ind.5 2006	Ind.6 2006	Ind.1 2011	Ind.2 2011	Ind.3 2011	Ind.4 2011	Ind.5 2011	Ind.6 2011
Abruzzo	39.2	16.9	5.8	19.9	78.6	28.3	36.9	33.0	4.1	21.2	78.2	34.9
Basilicata	15.7	7.8	4.7	17.5	78.3	15.1	17.1	18.0	2.9	26.0	77.7	36.0
Bolzano	20.2	46.3	6.1	41.3	81.0	140.4	20.3	58.6	5.5	28.6	87.1	168.4
Calabria	20.8	8.0	3.4	21.5	69.6	26.9	21.2	12.6	3.2	21.9	70.7	51.2
Campania	29.1	11.3	3.6	44.4	51.8	6.4	29.3	37.8	3.7	44.6	47.7	15.3
Emilia R.	11.6	33.4	12.2	44.3	71.9	5.4	11.8	50.1	9.9	39.2	78.8	11.9
Friuli V.G.	17.4	33.3	11.6	30.1	80.0	13.4	19.1	53.6	10.6	25.9	84.2	21.4
Lazio	25.0	11.1	7.7	44.0	61.5	5.5	25.6	20.1	6.4	45.1	61.1	8.9
Liguria	27.2	16.7	12.3	33.8	73.8	3.0	27.3	28.6	9.1	25.7	78.6	5.4
Lombardia	14.5	43.6	9.6	59.3	64.1	12.7	15.6	49.9	8.4	49.2	68.0	20.1
Marche	14.1	19.5	7.0	28.7	78.9	6.2	14.8	43.9	6.4	24.7	80.4	14.8
Molise	21.2	5.0	8.3	13.2	74.3	16.4	26.8	16.3	7.8	17.3	84.2	67.4
Piemonte	13.2	40.8	9.8	43.4	69.8	17.6	15.6	51.4	7.1	38.0	73.7	29.5
Puglia	24.5	8.8	14.1	34.8	64.0	5.5	24.5	16.5	11.9	33.1	67.9	25.8
Sardegna	17.7	19.8	11.6	19.3	75.9	6.7	23.6	47.1	9.5	16.0	80.8	19.0
Sicilia	21.1	6.6	8.4	34.6	57.6	2.7	23.5	11.2	7.7	35.7	59.0	13.8
Toscana	12.7	30.9	7.6	34.0	74.3	27.4	17.0	38.4	5.9	29.6	76.2	32.0
Trento	24.5	51.4	6.1	31.2	78.6	78.2	28.4	62.3	5.5	29.0	85.1	113.5
Umbria	14.2	24.5	14.0	30.9	77.0	26.9	15.0	36.8	9.9	22.0	79.4	32.1
Valle d'A.	23.4	31.3	6.8	27.7	82.9	220.2	30.3	41.9	4.9	19.1	86.4	232.7
Veneto	21.9	48.7	10.2	44.3	71.2	10.8	22.7	61.2	7.7	34.6	75.8	18.2
Italy	19.3	25.8	8.9	40.9	66.9	14.1	21.0	37.7	7.4	36.8	69.4	23.8

Table 1: Individual indicators - 2006 2011.

4 Main Results

As showed in table 2, at national level, between the two considered years, the value of the synthetic index increases of about 6 points. This increase in environmental quality affects all Italian regions, although at different levels. Since the MPI is based on arithmetic mean and on a variability function (composed by standard deviation and coefficient of variation), these positive results mean that the arithmetic means of the regions are constantly increasing and the variability functions have low values. The regions for which we observe the greatest increase in the index values are Sardegna and Valle d Aosta (both of them with a growth of the index of more than ten-point), followed by Molise and Liguria. The situation is more stable for regions such as Lazio, Calabria, Sicilia, Basilicata e Campania.These results are affected in particular by the increasing of separate waste collection in Italy and by the significant growth of electricity production from renewable sources.

Region	MPI 2006	MPI 2011	MPI 2011-MPI 2006
Abruzzo	114.2	118.7	4.5
Basilicata	104.5	108.4	3.8
Bolzano	114.3	122.3	8.1
Calabria	105.5	108.3	2.8
Campania	97.5	101.3	3.8
Emilia Romagna	94.7	102.1	7.4
Friuli Venezia Giulia	102.6	109.4	6.8
Lazio	97.3	100.0	2.7
Liguria	99.5	108.3	8.8
Lombardia	94.3	100.8	6.4
Marche	102.9	109.5	6.6
Molise	102.9	112.4	9.5
Piemonte	99.2	106.7	7.5
Puglia	92.5	99.1	6.6
Sardegna	100.6	112.6	11.9
Sicilia	95.2	98.3	3.1
Toscana	103.0	109.2	6.2
Trento	116.5	123.8	7.3
Umbria	96.5	106.1	9.6
Valle d'Aosta	118.1	128.3	10.2
Veneto	103.0	111.1	8.1
Italy	100.0	105.9	5.9

Table 2: The composite indices over time.

5 Conclusions

The observed improving trend of the composite index shows how the growing attention to environmental goals by policy makers is producing effects on environment quality, even if the trend of some indicators is influenced also by the economic downturn (e.g. the reduction of CO2 emissions linked to the contraction of industrial production).

Acknowledgments. Par.1 - P. Ungaro; Par.2 - M. Mazziotta; Par.3 - V. Talucci; Par.4 - C. Lucarelli, M. Mazziotta, V. Talucci, P. Ungaro; Par.5 - C. Lucarelli

References

[1] De Muro, P., Mazziotta, M., Pareto A. (2011). Composite Indices of Development and Poverty: An Application to MDGs. *Social Indicators Review* **104**, 1–18.

[2] Mazziotta, M., Pareto A. (2013). A Non-compensatory Composite Index for Measuring Well-being over Time. *Cogito. Multidisciplinary Research Journal* **Vol. V, no. 4**, 93–104.

[3] UN, 2013, FDES - Framework for the Development of Environment Statistics, *http://unstats.un.org*.