MEASURING LOCAL WELL-BEING: A COMPARISON AMONG AGGREGATIVE METHODS FOR THE EQUITABLE AND SUSTAINABLE WELL-BEING

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1. Introduction

A specific requirement in analysing well-being at local level is to bring out territorial disparities in order to assess the equity dimension of well-being and the territorial cohesion. In this work we explore different aggregation methods using the elementary indicators released by Istat under the "Provinces' BES" Project[1].

After selecting 41 indicators from the original dataset of 88 indicators, available for the year 2014, we apply three different aggregation methods, consisting of a weighted average of the standardized indicators. Firstly, we compute the Adjusted Mazziotta-Pareto Index (AMPI) to account for horizontal variability. Then we propose a different aggregation procedure, based on the Gini index (GW) that accounts for vertical variability. Finally, we propose a mixed approach that accounts both for horizontal and vertical variability, based on the Adjusted Mazziotta-Pareto but modified using a weighting system based on the Gini coefficients of the elementary indicators (GAMPI).

The rest of the paper is structured as follows: Section 2 presents the methodology for the construction of composite indexes; in details after describing the adopted normalization method, we describe, in details, the three aggregation methods. Section 3 presents the application of the above-mentioned methods to the Provinces' BES dataset. We compute the ranking correlation among the ranking produced by GW, AMPI and GAMPI. In addition, we focus on the GAMPI methods, classifying provinces in decile according the value of the aggregate indicator for each domain and finally, we compute the correlation among composite indicators of each domain. Section 4 concludes.

[1] The Province's Bes Project was launched in 2011 as a pilot study by the Province of Pesaro e Urbino in partnership with Istat, and from 2013 it has been extended other Italian Provinces and Metropolitan Cities. In 2015 it was listed in the National Statistical Programme as Statistical Information System.

2. Methodology

Since data have different unit of measurement, a preliminary step is necessary, in order to ensure the comparability. Among the huge class of normalization methods, we apply the methodology adopted in Mazziotta and Pareto (2016). Here, we apply the so-called *re-scaling* approach according to two '*goalposts'*, such that the interval length is one and a reference value (i.e. the Italian average) is the central value of the range (that is 0.5). More in details, let us define a matrix X_h for each well-being domain $h = 1, \dots, H$, whose the general element x_{ijh} is the value the of the *j-th* elementary indicator of the domain *h* for the *i-th* local unit (e.g., the province), with $j = 1, \dots, n_h$ and $i = 1, \dots, N$. We denote by $\mathrm{Max}_{.jh}$ and $\mathrm{Min}_{.jh}$ respectively the minimum and the maximum value of the indicator *j* of the domain *h* across all the local units, whereas and $\mathrm{Rif}_{.jh}$ represents a reference value, that is the average value for any indicator. Following Mazziotta and Pareto (2016) we compute the two *'goalposts'*, that is $\underline{x}_{.jh} = Rif_{.jh} - \Delta_{.jh}$ and $\overline{x}_{.jh} = Rif_{.jh} + \Delta_{.jh}$ where $\Delta_{.jh} = (Max_{.jh} - Min_{.jh}) / 2$.[2] The goalposts allow scaling indicators; in addition, the formulation captures changes over time since the reference values could be set as the extreme values of each indicator over the time period considered. We note that the goalposts are obtained adding or subtracting the quantity $\Delta_{.jh}$ obtaining the new minimum $\underline{x}_{.jh}$ and maximum $\overline{x}_{.jh}$, respectively. In addition, these values enter in the normalization step, that is, the normalized indicator *j* belonging to domain *h* for the *i*-th province, denoted with I_{ijh}, is then computed as follows:

$$\begin{cases} I_{ijh} = \dfrac{x_{ijh} - \underline{x}_{.jh}}{\overline{x}_{.jh} - \underline{x}_{.jh}} & (1)\ \textit{if the indicator has a positive polarity} \\[2ex] I_{ijh} = \dfrac{\overline{x}_{.jh} - x_{ijh}}{\overline{x}_{.jh} - \underline{x}_{.jh}} & (2)\ \textit{if the indicator has a negative polarity} \end{cases}$$

Equations (1) and (2) allow the normalization of the indicators according to the relation, namely polarity, with the phenomenon to be measured. That is, if the indicator has positive 'polarity', indicating that an increase in the indicator corresponds to an increase in the overall domain, equation (1) is used. By contrast, if the indicator shows negative relationship with the phenomenon, then we adopt the normalization expressed by equation (2).

Finally, a Linear Scale Technique is here adopted to re-scale indicators into a fixed range, that is an interval of length 60, such that the Italian mean (goalposts) is

[2] As observed in Mazziotta and Pareto (2016), using goalposts the re-scaling of the elementary indicators takes account changes over time.

fixed and equal to 100 (Mazziotta and Pareto, 2016; Massoli et. al., 2014). Formally:

$$r_{ijh} = I_{ijh} \cdot 60 + 70$$

and r_{ijh} ranges in [70,130].

Using r_{ijh} coefficients, we compute the simple arithmetic mean of the elementary indicators among a domain h, that is:

$$EW_{ih} = \sum_{j=1}^{n_h} \left(r_{ijh} \cdot \frac{1}{n_h} \right)$$

where n_h is the number of elementary indicators in the h-th domain and i denotes a generic local unit.

2.1. Horizontal variability: The Adjusted Mazziotta-Pareto Method

Since 2015, ISTAT (2015) has adopted a non-compensatory approach based on a penalty function that is the so-called adjusted Mazziotta and Pareto (2013a, 2016), hereafter (AMPI). It is based on the arithmetic mean of the elementary indicators, adjusted by a function that takes into account the horizontal variability of the indicators. Thus, the AMPI for the i-th local unit and the h-th well-being domain is given by:

$$AMPI_{ih} = EW_{ih} \pm S_{ih} \cdot cv_{ih}$$

where EW_{ih} is the arithmetic mean of the normalized indicators, and S_{ih} and cv_{ih} are respectively the standard deviation and the coefficient of variation of all the normalized indicators r_{ijh} belonging to domain h for local unit i, i.e. $S_{r_{ih}} = \sqrt{\frac{\sum_{j=1}^{n_h} \left(r_{ijh} - EW_{ih} \right)^2}{n_h}}$; $cv_{ih} = \frac{S_{ih}}{EW_{ih}}$ and the double sign depends on the polarity of the composite index with respect to the well-being. The negative sign (-) is used when the composite indicator EW is positively related to the construct of well-being, while the positive sing (+) when EW is negatively related to well-being.

Thus, the index is a combination of the average effect (the additive function - EW_{ih}) and the penalty effect (the function of horizontal variability - $S_{ih} \cdot cv_{ih}$), based on the variability among indicators in that province.

This method penalizes the local units that, mean being equal, present a more unbalanced distribution among the indicators values. Therefore, if within a BES domain, an Italian province presents a low value in one indicator and a high value in another, then that province receives a penalty without compensation. On the contrary, if there is a low variability among the indicators for that province, than the penalty effect is minimal. Despite all the components have the same importance in computing the composite index, to obtain a high value of the composite index, all the elementary indicators must assume high values. (Mazziotta and Pareto, 2013b).

However, applying the AMPI method to the BES at NUTS3 level, what emerges is that, within each domain, the contribution of the factor $S_{ih} \cdot cv_{ih}$ is small. In fact, if we compute the ranking correlation produced by AMPI and the ranking obtained removing the penalty coefficient, we observe that for all the domains, it ranges in [0.87; 0.99].[3]

2.2. Vertical variability: weighting using Gini

To overcome this drawback, we propose a different approach, introducing a weighting schema based on the Gini index of concentration.

More in details, within each domain, the weight associated to each elementary indicator is calculated as the Gini index of that indicator normalized by the sum of the Gini indices of all indicators in the same domain. Therefore, the composite index for the i-th local unit and the h-th well-being domain is defined as:

$$GW_{ih} = \frac{1}{G_h} \cdot \sum_{j=1}^{n_h} \left(r_{ijh} \cdot G_{.jh} \right)$$

where $G_{.jh}$ represents the Gini index of the j-th indicator belonging to the h-th domain and $G_h = \sum_{j=1}^{n_h} G_{.jh}$.

A possible drawback in the use of the Gini index is that it is usually defined for transferable variables. However, according to Becchetti et al. (2014), the possibility of redistribution is not essential since in this situation, the Gini index can be considered as a synthetic measure of the distribution of resources.

In addition, the use of the Gini index has also a theoretical justification since it is in line with the recommendations by the Commission on the Measurement of Economic Performance and Social Progress, according to which average measures should be accompanied by indicators reflecting their distribution (Stiglitz, et al. 2009).

Compared to the AMPI approach, these weights may be considered as a vertical variability coefficient: a more unequal distribution of an elementary indicator among provinces implies a greater weight associated to this indicator (Chelli et. al 2015).

[3] The results of the rank-correlation are available upon request.

Therefore, this aggregation method emphasizes the differences resulting from to more variables indicators and benefits those provinces with the highest values in the indicators which are more unequally distributed among the provinces. The peculiarity of this approach is to assume that the relative importance of the elementary indicators depends only on their distributions among the Italian provinces.

2.3. An unified approach: the Gini-based adjusted Mazziotta-Pareto Index

Since both methods have advantages, we decide to merge.

The ***Gini-based adjusted Mazziotta-Pareto Index (GAMPI)*** modifies the adjusted Mazziotta-Pareto Index, by computing first a Gini-based weighted average of the elementary indicators, and then adjusting the weighted mean by the *penalty* function. The GAMPI for the ***i***-th local unit and the ***h***-th domain is given by:

$$GAMPI_{ih} = \frac{1}{G_h} \cdot \sum_{j=1}^{n_h} \left(r_{ijh} \cdot G_{.jh} \right) \pm S_{ih} \cdot cv_{ih} = GW_{ih} \pm S_{ih} \cdot cv_{ih}$$

Compared to the AMPI, the *mean* effect is adjusted by the *vertical variability* of the elementary indicators, while the *penalty* function considers the *horizontal variability* of the indicators in each province.

Similar to the *GW* method, greater weights are given to those indicators with more unequal distributions across provinces, while the *penalty* function benefits those provinces with a balanced distribution of the indicators of the same domain. The advantage of this approach is to consider both the variability of the indicators belonging to the same BES domain for a specific province (*horizontal variability*) and the distribution of a specific indicator across all the Italian provinces (*vertical variability*). Therefore, this approach penalizes more the provinces having both low values in the indicators with a more unequally distribution among the Italian provinces and with greater variability among the indicators within the same domain.

3. An illustrative example

The starting point of the analysis is a subset of the 88 variables constituting the Provinces' BES dataset for 2014. (Table 1). The step of selection of the 41 indicators available for 110 Italian province allowed us to improve the relevance of the indicators to the BES construct, as well as the quality of the dataset since the reliability, robustness and significance at this territorial level are not always satisfactory (ISTAT, 2015 pp. 52 and 125).

Table 1 – *List of elementary indicators for each domain*

Domain	Indicator	Sign
1 - Health	Life expectancy at birth (male)	+
	Life expectancy at birth (female)	+
	Avoidable mortality rate	-
2 - Education and Training	Early leavers from education and training	-
	People of working age with secondary education degree or lower	-
	Student's level of literacy	+
	Student's level of digital competences	+
	Participation in lifelong learning (25-64 years)	+
3 - Work and life balance	Non participation rate (15-74 years)	-
	Gender difference in non-participation rates (F-M)	-
	Employment rate (20-64 years)	+
	Gender differences in employment rates (M-F)	-
	Youth employment rate (15-29 years)	+
	Risk of severe accidents at work	-
4 - Economic well-being	Gross disposable income per household	+
	Average amount of family assets	+
	Gender differences in the average wage of employees (M-F)	-
	Age groups differences in the average wage of employees	-
5 - Social relationship	Non-profit organizations	+
	Volunteers in no-profit organizations (per 100 residents aged 14 and over)	+
6 - Politics and istitutions	Turnout in the European Parliament elections	+
	Turnout in Provincial councils' elections	+
	Percentage of women elected in municipal councils	+
	Percentage of young people (<40 years old) elected in municipal councils	+
7 - Security	Violent crimes reported	-
8 - Landscape and cultural heritage	Conservation of the historic urban fabrics	+
	Density of urban parks of historical interest	+
	Museums and similar institutions	+
9 - Environment	Urban green areas	+
	Overruns of the daily limits of air pollution -	-
	Energy produced from renewable sources (electricity)	+
	Landfill storage of waste	-
10 - Research and innovation	Propensity to patent (applications)	+
	New graduates in S & T (total in the year)	+
	Industries specialization in knowledge-intensive sectors	+
11 - Quality of services	Irregularities in electricity supply	-
	Children (0-2 years old) receiving services for early childhood	+
	Separate collection of municipal waste	+
	Prisons overcrowding index	-
	Regional health services outflow (hospital admittance)	-
	Urban public transport networks density	+

Table 2 – *Rank correlation among synthetic methods in each domain*

Health	GW	AMPI	GAMPI	**Education and training**	GW	AMPI	GAMPI
GW	1			GW	1		
AMPI	0,9051	1		AMPI	0,9133	1	
GAMPI	0,9989	0,9099	1	GAMPI	0,9983	0,9169	1
Work and life balance	GW	AMPI	GAMPI	**Economic well-being**	GW	AMPI	GAMPI
GW	1			GW	1		
AMPI	0,995	1		AMPI	0,9406	1	
GAMPI	0,9982	0,9963	1	GAMPI	0,9524	0,9895	1
Social relationships	GW	AMPI	GAMPI	**Politics and institutions**	GW	AMPI	GAMPI
GW	1			GW	1		
AMPI	0,9982	1		AMPI	0,9353	1	
GAMPI	0,9999	0,9983	1	GAMPI	0,9852	0,968	1
Landscape and culturale heritage	GW	AMPI	GAMPI	**Environment**	GW	AMPI	GAMPI
GW	1			GW	1		
AMPI	0,9025	1		AMPI	0,9895	1	
GAMPI	0,9887	0,9082	1	GAMPI	0,9943	0,9911	1
Research and innovation	GW	AMPI	GAMPI	**Quality of services**	GW	AMPI	GAMPI
GW	1			GW	1		
AMPI	0,8772	1		AMPI	0,9768	1	
GAMPI	0,9973	0,8716	1	GAMPI	0,9949	0,984	1

First of all, with the 41 indicators, we compute the correlation among GW, AMPI and GAMPI (Table 2). What emerges is the high correlation among the three methods.

As illustrative example, we compute the GAMPI index. Figure 1 provides a geographical comparison of the Italian provinces in each BES domain. The *"Work and life balance"* and *"Research and innovation"* are the domains that better differentiate the provinces. There is, in fact, a clear gap between the provinces in the North, in the Center and in the South of Italy, which highlight the detriment of the southern provinces. The latter are also disadvantaged in the domains *"Quality of services"* and *"Social relationships"*, excluding the Sardinian provinces. Conversely, the South of Italy is advantaged in environmental domains as much as some northern provinces, such as the provinces of Aosta, Trento and Bolzano. The provinces in the North of Italy show the best performances in the domains *"Health"* and *"Education and training"*. In addition, they are advantaged in *"Economic well-being"* domain, as a consequent of a more developed economic activity. Finally, the provinces in the Center present better performance in

"Landscape and cultural heritage". In addition, we account for the degree of correlation among the BES domains (Table 3).

Table 3 shows the value of the correlation coefficients among the composite indicators of each domain resulting from the GAMPI approach. The lowest levels of correlation are in correspondence with the domain "*Environment*", which is poorly correlated with all the domains and in particular with "*Health*", "*Education and training*" and "*Work and life balance*", for which the coefficients are almost null. On the contrary, the highest level of correlation is registered between "*Work and life balance*" and "*Quality of services*" (0.8082).

Table 3 – *Correlation among composite indicators of each domain for GAMPI approach*

D1	1									
D2	0.395	1								
D3	0.6473	0.5065	1							
D4	0.3313	0.1493	0.403	1						
D5	0.511	0.3139	0.6738	0.4584	1					
D6	0.5425	0.2837	0.5337	0.3647	0.3039	1				
D7	0.3271	0.2207	0.3889	0.2673	0.47	0.1694	1			
D8	0.0019	-0.0936	-0.068	0.1726	0.3744	-0.1297	0.4061	1		
D9	0.5716	0.4933	0.7173	0.1319	0.3559	0.5044	0.1298	-0.285	1	
D10	0.628	0.3414	0.8082	0.3511	0.5537	0.4702	0.2039	-0.2015	0.6934	1

The fact that none of the values of the correlation coefficient is particularly high may, interestingly, reveal that the BES domains are not substitutable but rather complementary. Hence, a possible further step of aggregating all the domain-specific composite indices into an overall composite index of well-being may reveal to be a dangerous choice, since it would lose important information.

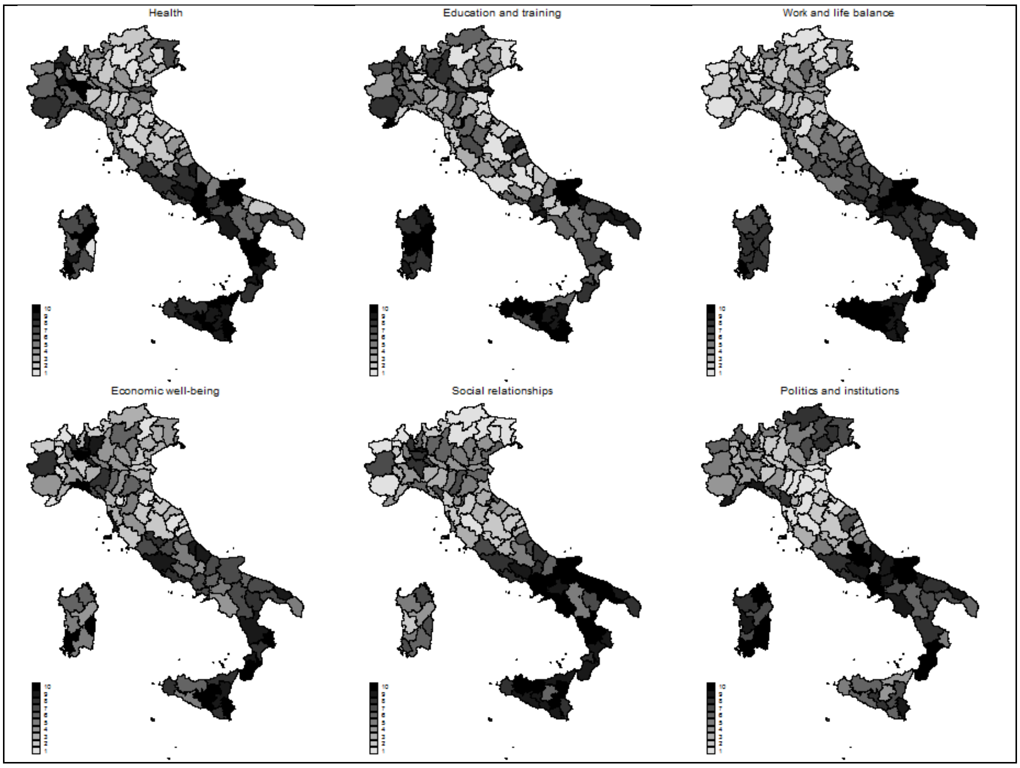
4. Conclusive remarks

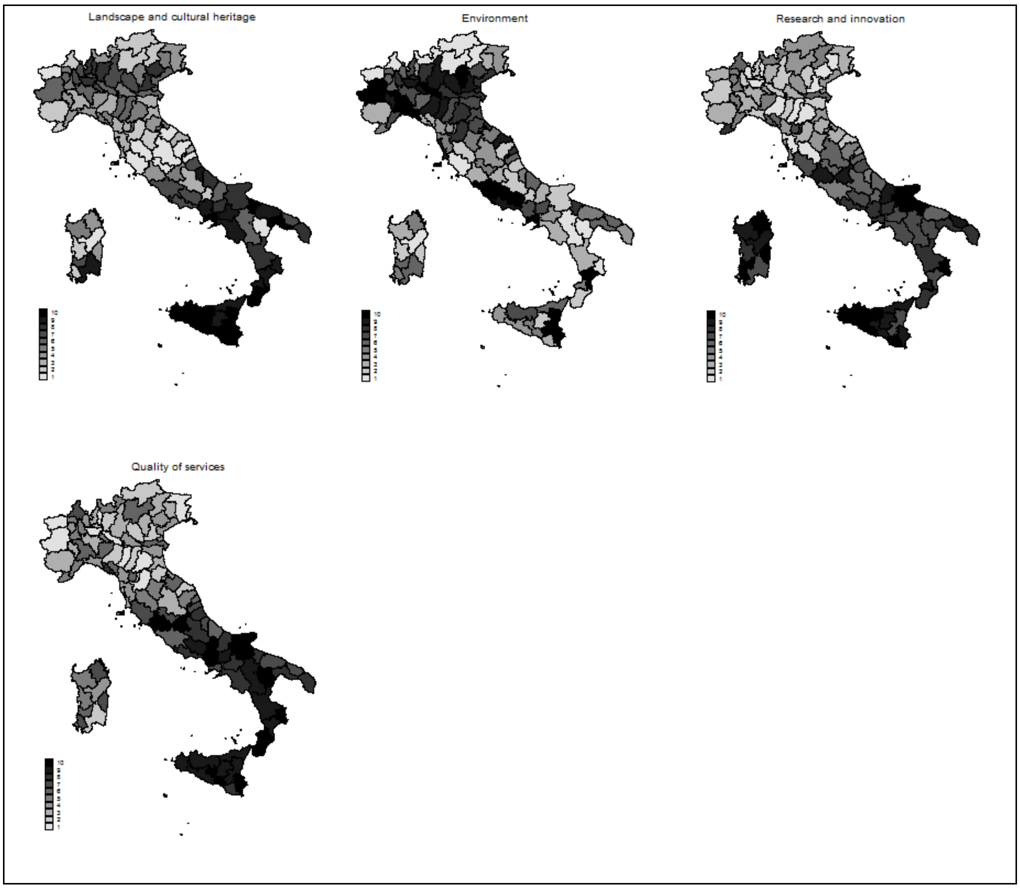
There is an increasing interest on the aggregation of elementary indicators. Beside the simple arithmetic mean, there are several methods to aggregate information. However, there is no better method; each synthetic method reflects a different nature of the composite indicator that emphasizes a different priority in defining the well-being (Wilson et al. 2007).

Here, we explore different methods of aggregation for the elementary indicators constituting the Italian Equitable and Sustainable Well-being Project for Italian Provinces. And we propose a new method, called *Gini-based adjusted Mazziotta-Pareto Index* (GAMPI) that accounts both for vertical and horizontal variability.

Further researches will be conducted to analyze and compare additional aggregation methods.

Figure 1 – *Maps of Italian provinces (ranking by deciles) for GAMPI in each domain*.





References

BECCHETTI L., MASSARI R., NATICCHIONI P. 2014. The drivers of happiness inequality: suggestions for promoting social cohesion. Oxford Economic Papers, Vol. 66, No. 2, pp. 419–442

MAZZIOTTA M., PARETO A. 2016. On a Generalized Non-compensatory Composite Index for Measuring Socio-economic Phenomena, *Social Indicators Research*, Vol. 127, No. 3, pp. 983-1003.

MAZZIOTTA M., PARETO A. 2013a. A Non-Compensatory Composite Index for Measuring Well-Being over Time. *Cogito. Multidisciplinary Research Journal*, Vol.5, No. 4, pp 93-104.

MAZZIOTTA M., PARETO A. 2013b. Methods for constructing composite indices: one for all or all for one. *Rivista Italiana di Economia Demografia e Statistica*, Vol. 67, No.2, pp. 67-80.

MASSOLI P., MAZZIOTTA M., PARETO A., RINALDELLI C. 2014. Indici compositi per il BES. *Giornate delle ricerca in Istat*. Istat.

ISTAT (2015), Il benessere equo e sostenibile in Italia, Istat, Roma.

STIGLITZ J. E., SEN A., FITOUSSI J. P. 2009. Report by the commission on the measurement of economic performance and social progress. Commission on the Measurement of Economic Performance and Social Progress, Paris.

CHELLI F. M., CIOMMI M., EMILI A., GIGLIARANO C., TARALLI S. 2015. Comparing Equitable And Sustainable Well-Being (Bes) Across The Italian Provinces. A Factor Analysis-Based Approach. *Rivista Italiana di Economia Demografia e Statistica*, Vol. 69, No. 3, pp. 61-72.

WILSON J., TYEDMERS P., PELOT R. 2007. Contrasting and comparing sustainable development indicator metrics. *Ecological indicators*, Vol.7, No. 2, pp.299-314.

SUMMARY

Measuring local well-being: a comparison among aggregative methods for the equitable and sustainable well-being

Within the "BES' Provinces" Project this work aims to compare different synthesis techniques of elementary indicators for each BES domain. Firstly, 41 elementary indicators are selected from the original dataset of 88 indicators, available for the year 2014, which guarantee robustness, reliability and relevance in accordance with the BES meaning.

Motivated by the debate on the need to summarize the information arising from a large set of variables, in this paper we discuss three different aggregation methods: the Adjusted Mazziotta-Pareto Index, the arithmetic mean weighted by the Gini coefficients of the elementary indicators and a mixed approach based on the two.

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