DEPARTMENT OF SOCIAL SCIENCES
AND ECONOMICS

SAPIENZA
UNIVERSITÀ DI ROMA

ISSN 2532-117X
Working papers
DIPARTIMENTO DI SCIENZE
SOCIALI ED ECONOMICHE
[online]

PhD COURSE IN
APPLIED SOCIAL SCIENCES

WORKING PAPERS SERIES

n. 1/2018

On the Construction of Composite Indicators for Measuring some Domains of Well-being at the Municipal Level

Author: Matteo Mazziotta

SAPIENZA - UNIVERSITY OF ROME
P.le Aldo Moro n.5 - 00185 Roma T (+39) 06 49910563 F (+39) 06 49910231
CF 80209930587 - P.IVA 02133771002

On the construction of composite indicators for measuring some domains of well-being at the municipal level[1]

Matteo Mazziotta
Sapienza University of Rome

The measurement of multidimensional socio-economic phenomena allows expanding studies and analysis by overtaking classic accounting measures and providing new information even for very small territorial details. Among these phenomena, the theme of well-being plays a central role because it is highly studied at national and international level. In addition, the use of administrative sources for statistical purposes allows the calculation of individual and composite indicators up to the municipal level (and beyond) providing to citizenship and policy makers interesting analysis tools. In this context, the use of composite indicators is essential to synthesize information and make it readable by an eye that is not used to this type of analysis. The paper aims to present an experiment conducted on the Italian municipalities where well-being individual indicators are calculated starting from administrative sources; and then, composite indicators are computed in order to have a unidimensional measure that can help the policy makers for the economic planning of the territory.

INTRODUCTION

Well-being is a complex phenomenon. Multidimensionality is recognized in literature as its main feature. This phenomenon is in some respects elusive and difficult to monitor, and the definition is the combination of heterogeneous components, which assume different meanings in different contexts. A universally accepted definition of well-being does not exist (yet): each country attributes importance to dimensions that for others may not be as relevant, consistent with their culture and social dynamics. Accurate measurement of well-being is a prerequisite for the implementation of effective welfare policies, which, through targeted actions in the most critical areas, are geared to the progressive improvement of living conditions. Until some time ago, such a plurality of components was poorly valued, believing that the only income dimension could represent in an exhaustive way such a complex reality. For many years, GDP (Gross Domestic Product) has been an indisputable landmark for states all over the world,

[1] PHD student at the Department of Social and Economic Sciences; matteo.mazziotta@uniroma1.it

playing the key role in defining, implementing and evaluating the effects of government action. Recently, the international debate has questioned the supremacy of GDP, and initiatives have been launched which, through the involvement of a growing number of countries, aim to develop alternative ways of measuring well-being that assign the same value to its components, Economic, social and environmental.

Since well-being, as mentioned above, is a multidimensional phenomenon then it cannot be measured by a single descriptive indicator and that, instead, it should be represented by multiple dimensions. It requires, to be measured, the "combination" of different dimensions, to be considered together as components of the phenomenon (Mazziotta and Pareto, 2013). This combination can be obtained by applying methodologies known as composite indicators (Salzman, 2003; Mazziotta and Pareto, 2011; Diamantopoulos et al., 2008).

In this ever-evolving scenario, the Italian experience is represented by the BES (Equitable and Sustainable Well-Being) project that is now considered globally as the most advanced experience of study and analysis. It consists in a dashboard of 134 individual indicators distributed in 12 domains. In the last two BES reports, published in December 2015 and 2016 by Istat (Italian Institute of Statistics) (Istat, 2015; Istat, 2016), composite indicators at regional level and over time were calculated for the 9 outcome domains, creating a unique precedent in the official statistics at international level.

Recently, the debate has become from a scientific to a policy scope: parliamentary and local administrators are affirming the necessity to link the Istat well-being indicators to interventions/actions in the socio-economic field, thus constructing an even stronger connection between official statistics and policy evaluation. In fact, the Italian Parliament has finally approved on 2016 July 28 the reform of the Budget Law, in which it is expected that the BES indicators, selected by an *ad hoc* Committee, are included in the Document of Economics and Finance (DEF). The new regulations also provide that by February 15th of each year Parliament receives by the Minister of Economy a report on the evolution of the BES indicators. A Committee for equitable and sustainable well-being indicators is established, chaired by the Minister of Economics and composed by the President of Istat, the Governor of the Bank of Italy and two experts coming from universities or research institutions (Mazziotta, 2017).

The project, from national, is getting local and already several local authorities, although they not have legislative obligations, are studying the well-being indicators of their territory. With these assumptions, it seems necessary to calculate well-being measures for all Italian municipalities so that administrators and citizens can dispose of them to understand and decide better policies. Since the current statistical surveys do not provide socio-economic indicators disaggregated at level of municipalities (Census is the only source, every ten years and it does not collect all the information contained in the BES), it is necessary to use administrative sources, hopefully, collected in informative systems.

The paper aims to present an experiment conducted on all the municipalities of Italy where three domains of BES are selected (Education, Labour and Economic well-being). The individual indicators are calculated starting from administrative sources and then composite indicators are computed in order to have a unidimensional measure. The theoretical framework adopted is represented, therefore, by the conceptual and methodological one developed by Istat and CNEL (National Council of Economy and

Labor) for the BES project (Istat, 2015). The structure of the three domains and the selection of indicators derived from the national BES. In each of the three domains, two individual indicators are selected so that the starting matrix has 8,048 rows (the municipalities) and 6 columns (the indicators). Composite indicators with different methods are calculated in order to assess the robustness of the methodologies. The results present interesting reflections also in the key of social inclusion.

ADMINISTRATIVE DATA SOURCES

Starting from 2021, the population census and the master sample on households will provide many indicators each year at the municipal level. Integration between direct surveys and administrative sources is the main route of modern statistics where the timeliness of the information must be associated with a very fine spatial detail. In view of the enhancement and integration of administrative sources, the experimentation uses dataset provided by the project ARCHIMEDE (Integrated Archive of Economic and Demographic Micro Data), that collects micro-data relative to the universe of individuals and households living in Italy. Thus, it is possible to calculate indicators relating to family types, income, employment status, job security, social problems, level of education and training and other. It is also possible to estimate, for each municipality, the municipal flows for study or work, and the average mobility times.

Istat Project ARCHIMEDE aims at expanding Istat information by producing longitudinal paths (for example, social and economic) and cross-sectional collections of micro data to be made available to users and useful to social and economic research, to sectorial and territorial planning, and to public policy evaluation at national, regional and local levels. This objective has to be achieved through the exploitation of administrative database information contents integrated into Istat platform SIM (Integrated Micro data System). During the year 2013 three experiments were designed and conducted in relation to the themes "Resident population" (identification, classification and quantification of the population using the territory), "Precarious employment" (identification, classification and qualification of workers with precarious employment contracts) and "Household socio-economic conditions" (construction of an information structure on households to analyse various aspects of their socio-economic status). The purpose of the experimentation was to assess the real project potential on the one hand, and to propose and assess the feasibility of specific statistical products and systems for the dissemination of information outputs, on the other (Garofalo, 2014).

Recently, several quality analysis of ARCHIMEDE data have been made. Obviously it is not possible to measure quality to communal detail as there are no benchmarks of comparison. However, starting with ARCHIMEDE, the socio-economic indicators are calculated at regional level and compared with those from direct surveys: the differences are very small and the reasons are known.

INDIVIDUAL INDICATORS

The use of data sources listed above allows to calculate, at this step of the research, 6 individual indicators for all the Italian municipalities in the year 2014: in fact, as

mentioned in the introduction, the starting matrix is composed by 8,048 rows and 6 columns. Using ARCHIMEDE, it is possible to construct many individual socio-economic indicators for the several domains of well-being. In particular, in this paper, the focus is on three well-being domains that represent the socio-economic condition of citizens at the municipal level: obviously this is an experimentation that, in the continuation of research, will be extended to all domains of well-being extracted from the administrative archives. Below, domains and individual indicators are presented. "Economic well-being": Income inequality Index; At risk of poverty rate; "Education": People with a university degree; Not (engaged) in Education, Employment or Training (NEET). "Labour": employment rate; Rate of job insecurity. It seems necessary to point out that the individual indicators taken from administrative sources can not be perfectly matched to those calculated by direct sample surveys since there are differences from a theoretical point of view. For example, the employment rate is calculated as a ratio between people of 20 to 64 years old enrolled in a population register with a regular employment on the total number of people enrolled in the population register of 20-64 years old: of course, irregular workers are excluded from this rate, and it is known that the population registered (resident) is not the same population living habitually in the generic municipality. Therefore, the employment rate is composed by a numerator and a denominator that are different, depending on whether the source is administrative or the classical sample survey on labor force. Likewise, the poverty indicators presented in this paper are based on Italian tax returns (administrative source) and not on the sample survey of households' consumptions; and education indicators are based on data from the Ministry of Education and Scientific Research. Conversely, sample surveys fail to provide data to communal detail and therefore, at this particular historical moment, researchers are trying to experiment with the best way to integrate them with administrative sources, even if this means dealing with distortion more or less significant. Recent experiments on the municipalities of Basilicata and Emilia Romagna have been made and the results have confirmed the validity of the use of administrative sources for statistical use.

The table with correlations of individual indicators selected for experimentation is presented below (see the appendix for the main characteristics on the construction of the indicators).

TABLE 1

CORRELATIONS AMONG INDIVIDUAL INDICATORS - YEAR 2014

Individual indicators	Income inequality	Poverty rate	NEET	University degree	Employ. rate	Job insecurity
Income inequality	1	0.082	0.079	0.274	-0.198	0.119
Poverty rate	0.082	1	0.635	-0.078	-0.885	0.447
NEET	0.079	0.635	1	-0.095	-0.700	0.331
University degree	0.274	-0.078	-0.095	1	0.024	-0.042
Employment rate	-0.198	-0.885	-0.700	0.024	1	-0.415
Job insecurity	0.119	0.447	0.331	-0.042	-0.415	1

It is interesting to note that the indicators "Income inequality" and "University degree" are basically not correlated to the others. There is a good positive correlation between "Poverty rate" and "NEET" (0.635) and strong negative correlations between "Employment rate" and "Poverty rate" (-0.885) and between "Employment rate" and

“NEET” (-0.700). Although for the measurement of the phenomenon a formative model is adopted and therefore the correlations between individual indicators are not of particular importance, it seems that the indicators are statistically very informative since these correlations are weak.

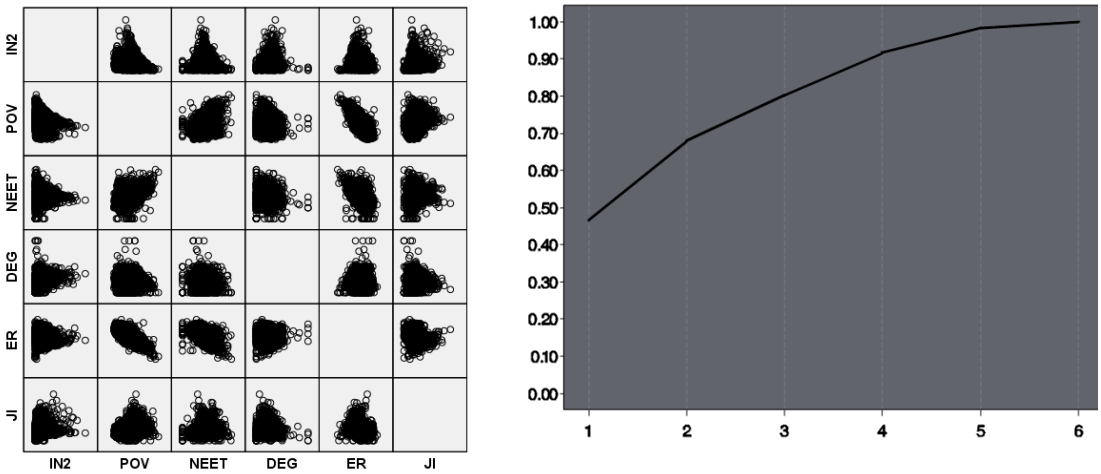

Fig. 1 – *Scatter plot matrix and scree plot of the individual indicators.*

In the Fig. 1, the scatter plot matrix shows graphically the correlations presented in Table 1, making even clearer the reciprocal influence among the indicators; the scree plot, obtained from a PCA on the six individual indicators selected, shows that the first two factors explain almost 70% of the variance, that is, the statistical information contained in the multidimensional construct.

COMPOSITE INDICATORS METHODOLOGY

In order to synthesize the individual indicators in a unique measure, a composite indicator is used and it is the official methodology adopted by Istat for BES project (and not only).

The Adjusted Mazziotta-Pareto Index (AMPI) is a partially non-compensatory composite indicator based on a standardization of the individual indicators, at the reference time, that makes the indicators independent from the unit of measure (De Muro et al., 2011). Therefore, all the individual indicators are assigned equal weights and also absolute time comparisons are allowed (Mazziotta and Pareto, 2016). In fact, a re-scaling of the individual indicators in the range (70; 130) according to two ‘goalposts’ is proposed, 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 (AMPI) are given below (Mazziotta and Pareto, 2016).

Given the matrix $X=\{x_{ij}\}$ with n rows (units) and m columns (individual indicators), we calculate the normalized matrix $R=\{r_{ij}\}$ as follow:

$$r_{ij} = \frac{(x_{ij} - \mathrm{Min}_{x_j})}{(\mathrm{Max}_{x_j} - \mathrm{Min}_{x_j})} 60 + 70$$

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[2], the complement of the formula aforementioned 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[3] of the adjusted MPI is given by:

$$\mathrm{AMPI}_i^{+/-} = \mathrm{M}_{r_i} \pm \mathrm{S}_{r_i} \mathrm{cv}_i$$

where $\mathrm{cv}_i = \mathrm{S}_{r_i} / \mathrm{M}_{r_i}$ is the coefficient of variation of the unit *i* and the sign ± depends on the kind of phenomenon to be measured. 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). A simple procedure for setting the 'goalposts' is the following. Let Min_{x_j} and Max_{x_j} be the overall minimum and maximum of the indicator *j* across all units and all years. Denoting with Ref_{x_j} the reference value for the indicator *j*, the 'goalposts' are defined as: $\mathrm{Ref}_{x_j} \pm \Delta$, where $\Delta = (\mathrm{Max}_{x_j} - \mathrm{Min}_{x_j})/2$[4].

The 'price' to pay for having final scores comparable over time is that individual indicators with different variability are aggregated. However, normalized indicators in an identical range have much more similar variability than original ones. For the mathematical properties of AMPI see Mazziotta and Pareto, 2016. In order to compare AMPI with a compensatory method, the arithmetic mean of the standardized values (using the same procedure of AMPI) is computed: in this way, the only differences between the methods are due to the function of synthesis.

MAIN RESULTS

In this section some results of the application to real data are presented. The map represents with different colours (dark green is the best) the intensity of the phenomenon "Socio-economic condition" measured by the composite indicator for all Italian municipalities (Fig.1). The higher the value the better is the performance.

[2] The indicator's "polarity" is the sign of the relation between the indicator and the phenomenon to be measured (+ if the individual indicator represents a dimension considered positive and - if it represents a dimension considered negative).

[3] It is a generalized form since it includes 'two indices in one'.

[4] Note that the normalized values will fall approximately in the range (70; 130).

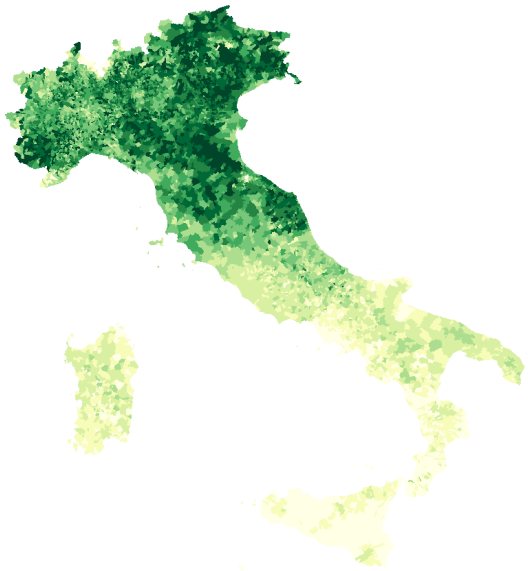

Fig. 2 – *Socio-economic condition computed by AMPI - 2014.*

The map is very informative (even too) in the sense that it seems difficult to understand what is the behavior of the phenomenon for such a small detail. However, the Figure 2 shows, as foreseeable, a net cut among the North, the Centre and the South of the country. The aim of the paper is also to show that it is possible to analyze municipal detail so that the general map of Italy should be used as an aid to identify areas where the phenomenon has particular characteristics, for example a weaker green in a northern municipality or a stronger green in a southern municipality. The composite indicator analysis for all municipalities must be a starting point for both micro-depth studies, but also for macro studies, such as measuring the correlation with other variables/indicators available at this territorial level.

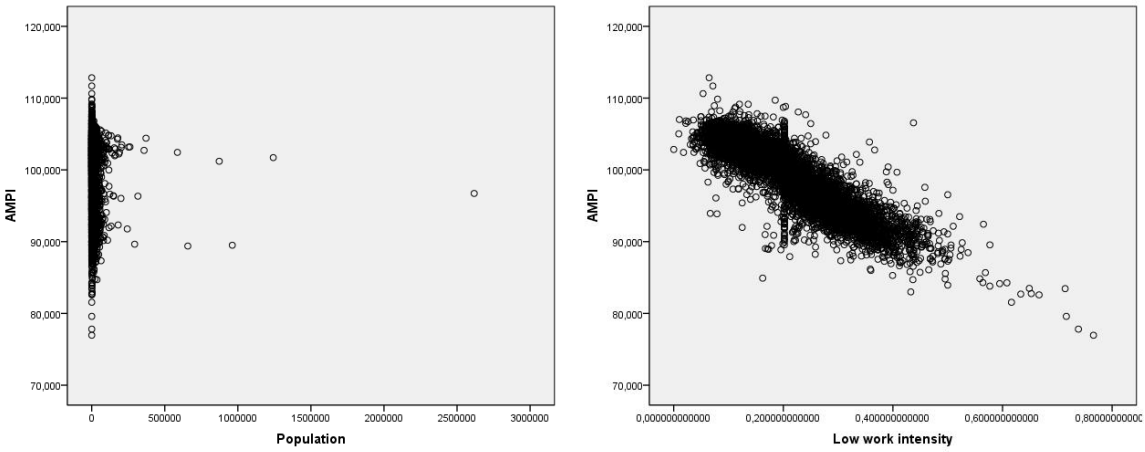

Fig. 3 – *Scatter plots between AMPI and Population/Low work intensity - 2014.*

The first idea is to correlate the composite indicator of socio-economic condition with the size of the municipality (Fig.3): the result is surprising since there is full uncorrelation (ρ = -0.029). This means that there is no factor related to the size of the municipality that can determine the socio-economic condition, and vice versa: these two informative contributions do not affect each other. And this is certainly a strength point of the composite index that can explain a multidimensional phenomenon that is independent from an important variable, especially in Italy, as the size of the municipality. However, the theme should certainly deserve a deepening by trying to do the analysis again with more aggregate territorial areas (regions or macro-regions).

Recently, at European level, the "Low work intensity" indicator is considered a valid measure of social exclusion: It is the percentage of families with work intensity less than 20% of their potential: work intensity is a measure of family members' participation in the labor market. “Severe material deprivation” and “Very low work intensity” are two out of the three components of the Europe 2020 Poverty and Social exclusion indicator: the third component is “At-risk-of-poverty”, and represents the monetary element of poverty and social exclusion (Eurostat, 2017). Since this indicator can be calculated by ARCHIMEDE using two administrative variables (regular employees and population register - see Appendix 1), a correlation with the composite indicator of socio-economic condition is calculated. Since the value is -0.896, then there is a strong negative correlation (Fig. 3), i.e. if the socio-economic condition of the citizens increases then the low work intensity decreases, and vice versa. Also in this case, the analysis seems to provide a good signal of the composite indicator's validity since the multidimensional phenomenon, composed by dimensions of income, education and labor, has a behavior that is absolutely consistent with one of the main indicators used in Europe to measure social exclusion.

In order to understand whether there is a compensatory effect among the individual indicators, AMPI is compared with a non-compensatory method i.e. the arithmetic mean of the standardized values with the min-max function (OECD, 2008). The correlation between the two composite indicators is very high (ρ = 0.998) so it can be stated that there is no compensatory effect and this is also confirmed by the scatter plot in Figure 4.

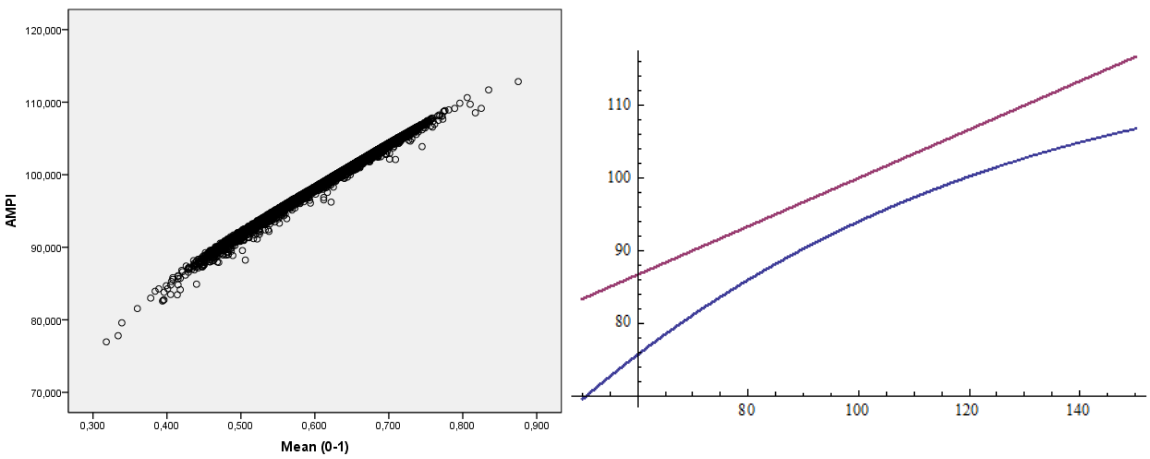

Fig. 4 – *Comparison between AMPI and Mean (0-1).*

Furthermore, the behaviors of the functions of the two composite indexes are confirmed by the graph to the right of Figure 4: the red line is the function of the arithmetic mean and the blue curve of AMPI. If horizontal variability is not equal to zero, the blue curve is always below the red line because AMPI is always smaller than the mean (this is the same behavior of the geometric mean). The scatter plot of Figure 4 perfectly confirms the theory even if the line and curve (imaginary) are much closer. The latter is a further proof that the compensatory effect between selected individual indicators is small.

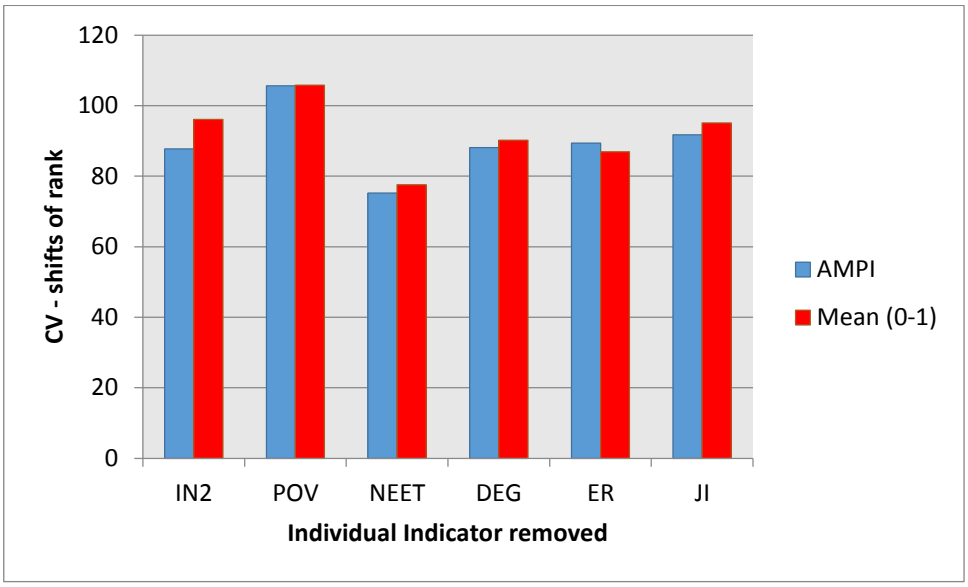

Fig. 5 – *Uncertainty analysis between AMPI and Mean (0-1).*

With regard to the Uncertainty Analysis (UA), an Influence Analysis (IA) on the two composite indicators is calculated: the aim is to assess the robustness of the composite indicators, in terms of capacity to produce correct and stable measures, and its discriminant capacity. In particular, IA wants to empirically quantify the 'weight' of each individual indicator in the calculation of the composite indicator. Given K individual indicators (K=6, in this case), K replications are conducted, removing each time a different indicator and calculating the values of the composite indicator based on the remaining K-1 indicators. For each replication, the rankings of the Italian municipalities are constructed according to the various methods and, for each municipality, the absolute differences of rank between the position in the original rank and the position in the ranking for the K-1 indicators are calculated. Subsequently, the arithmetic mean, the standard deviation and the coefficient of variation (CV) of absolute rank differences are calculated: obviously, the method with the lowest variation coefficients is the most robust because it is less influenced by disturbance factors (Mazziotta C. et al, 2010; Mazziotta and Pareto, 2017). Figure 5 mainly provides two pieces of information: the first is that AMPI is more robust than the Mean (0-1) since its CVs are substantially lower; the second is that the implicit weight of each individual indicator in determining the composite index is fairly constant. This can be seen from the uniformity of the bars and it is a very positive aspect since the weight of each individual indicator on the latent factor is similar.

CONCLUSIONS AND NEXT STEPS

The publication of the last two reports on Equitable and Sustainable Well-being (BES) by Istat is a central experience of study and socio-economic analysis for the entire international scientific community: composite indicators are calculated at regional level and over time for each of the nine outcome domains by creating a unique precedent in the official statistics at international level. Probably this very stimulating innovation has attracted the interest of policy makers at national and local level; hence several reflections were made not only in scientific journals but mostly on traditional media. The discussion is centered both on purely definitional aspects about the well-being of citizens and on methodological issues, more specifically the use of a set of individual indicators (dashboard) or on the application of composite indicators, because the scientific community is in agreement for supporting the multidimensionality of the phenomenon in a view "Beyond GDP" (Maggino, 2014). All this is even more relevant since the performance of well-being indicators have entered, by law, within the national budget and therefore public accounts (the reform of the budget law was approved by the parliament on July 28, 2016).

In this context, it seems important to provide high-quality statistics for the smallest territorial detail. Where traditional surveys cannot be of help because of too small sample size, then it is necessary to use administrative sources and/or big data. The research proposed in this paper is based on the selection of three domains from the BES (the total is twelve) that represent the socio-economic conditions of the citizens: Education, Labor and Economic well-being. From each domain, two individual indicators are extracted so that, based on a formative model (Diamantopoulos, 2008; Mazziotta and Pareto, 2017), they could well represent the multidimensional phenomenon. The six socio-economic individual indicators are available at level of Italian municipality (8,048) from an integrated system of administrative sources (collected in ARCHIMEDE). Composite indicators, obtained by AMPI, are calculated in order to measure the socio-economic condition of the 8,048 municipalities, so that for each of them a single measure is provided (to make multidimensional reality one-dimensional). This "exercise of democracy" has a double objective: in fact, these values can be very useful for the evaluation of the intervention's policies by local administrators and for the assessment of the administrators themselves by the citizens (OECD, 2008). This means that one of the most important phases of the research is the best practice for publishing these results so that everyone can have easy access in order to better understand the socio-economic context and decide independently through data recognized as impartial by the Community.

The experimentation on the data of six individual indicators seems to have achieved satisfactory results both methodologically and theoretically. Preliminary data analysis shows that the correlations among the indicators have a correct polarity and that some indicators are almost orthogonal to each other and therefore very statistically informative: so the goodness of the choice of indicators is also confirmed by an objective approach (a formative model is adopted, therefore, theoretically, correlations should not be relevant to the selection of the indicators). The composite index calculated on all Italian municipalities draws a well-known geography of social and economic conditions. In fact, the peninsula seems to be divided into three parts with the conditions getting worse going south. The North-east seems to be better than the North-west and

the Center-north better than the Center. The composite indicator and demographic amplitude are basically uncorrelated and this means that there is no link between the socio-economic condition of the municipality and its population size: rather there is a relation with localization in the Italian territory. However, the type of data available would require the analysis to be made for details of particular smaller areas as Local Labor Systems (LLS), neighborhoods of large cities or special sub-populations such as people with disabilities, homeless, people detained in prison, etc.. In fact, the main objective is to use this data for the evaluation of public policies and to provide an objective set of available social and economic measures to thematic experts and ordinary citizens in order to assess the performance of actions on the territory. In this regard, the strong correlation between the composite indicator and the indicator "Low work intensity" can mean that the six selected indicators are interpretable as the latent factor "Social inclusion", one of the most relevant issues for social-economic policy of any government (central or local). The research in this scientific field is making great strides. Nevertheless, it seems necessary that the use of administrative sources and big data (such as mobile data, scanner data and others) is associated with sample surveys that can, for example, collect types of subjective variables. This new scenario could change radically, on the one hand, the production of official statistics, and other, the analyses of socio-economic phenomena. In this regard, the aim of this research is to calculate composite indicators for all outcome domains of well-being for all Italian municipalities and, specifically, to focus on some of them where it is possible to measure subjective well-being: in this way, all the components of well-being would be represented and the study of the relationship between objective components and subjective components over time would be a very useful tool for social and economic analyses of the populations.

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APPENDIX

TABLE A1
SOCIO-ECONOMIC INDIVIDUAL INDICATORS OF WELL-BEING FOR ITALIAN MUNICIPALITIES

Domain and indicator	Description	Source
Education		
Persons who have obtained a university degree	Percentage of people aged 30-34 who have completed a university degree on the total number of persons aged 30-34	Istat: ARCHIMEDE project
NEET[1]	Young people who do not work and do not study (NEET): Percentage of people aged 15-29 neither occupied nor included in a course of education in the total number of persons of 15-29 years	
Labour		
Employment rate	Percentage of employed[2] of 20-64 years on the population of 20-64 years	Istat: ARCHIMEDE project
Rate of job insecurity	Percentage of temporary workers over the total employment [2]	
Economic well-being		
Income inequality index	Ratio of total income equivalent owned by 20% of the population with the highest income and the one owned by 20% of the population with the lowest income	Istat: ARCHIMEDE project
At risk of poverty rate	Percentage of people at risk of poverty, with an income equivalent to less or equal to 60% of the median income equivalent to the total of people living	

Notes of the table A1:
[1]Currently in ARCHIMEDE there is not the information on the attendance at professional training courses, so that this indicator at municipality level is an over estimation of the phenomenon.
[2] In ARCHIMEDE the people who have a working signal for at least one month in the year are considered as employed.