

# A Quantile Composite-Indicator Approach for the Measurement of Equitable and Sustainable Well-Being: A Case Study of the Italian Provinces

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**Abstract** An interesting measure for equitable and sustainable well-being has been proposed recently by the National Institute of Statistics in Italy and the National Council for Economy and Labour. It is called BES (from the Italian *Benessere Equo e Sostenibile*). A set of indicators, partitioned into several domains and themes, is used for measuring the BES. Taking into account prior knowledge of both the structure of this set of indicators and the relationships among them, the paper proposes a hierarchical composite model for measuring and modeling the BES of the Italian provinces. This hierarchical model allows us to synthesize individual indicators into single indexes in order to construct composite indicators at a global and a partial level. Moreover, we analyze the relationships among the different domains and themes as well as the effects of these on equitable and sustainable well-being, in order to search for strongly influential factors. In order to estimate the

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parameters of the model, we use both Partial Least Squares path modeling and a new method, called Quantile Composite-based path modeling. In particular, Partial Least Squares path modeling is used to estimate average effects in the network of relationships between variables, while with Quantile Composite-based path modeling we investigate whether the magnitude of these effects changes across different parts of the variable distributions, providing a more complete picture and uncovering specific local leveraging factors for improvement. A final ranking of the Italian provinces, according to the BES composite indicator, is also provided at the national level and for different geographic areas of Italy.

**Keywords** Equitable and sustainable well-being · Composite indicators · Hierarchical composite model · Partial Least Squares path modeling · Quantile regression

## 1 Introduction

The requirement for developing alternative well-being measures to the classical gross domestic product (GDP) actually dates back to the 1990s when studies related to the measurement of sustainable and human development in different countries (among others, the Human Development Index<sup>1</sup> proposed by the United Nations) started to play a relevant role in the political and social debate.

By that time, the vision shared at an international level was that the progress of a country cannot be measured by looking just at GDP, but rather that it is necessary to monitor both economic and social progress (Maggino and Sorvillo 2015).

In the last decade the main stages of the international debate are marked by the declaration at the 2007 Organisation for Economic Co-operation and Development (OECD) World Forum,<sup>2</sup> the "Stiglitz Report" (Stiglitz et al. 2009), the "Beyond GDP"<sup>3</sup> conference supported by the European Commission and the "Europe 2020" strategy<sup>4,5</sup> (ONS 2011). The development of high quality statistical methodologies providing a shared vision of well-being and properly supporting the decision-making processes and the monitoring of the Countries performances is one of the main topics in the debate of the last decade.

In this context, in 2010, the Italian National Institute of Statistics (Istat) and the National Council for Economy and Labour (Cnel) launched a new project to measure equitable and sustainable well-being, called BES<sup>6</sup> (from the Italian *Benessere Equo e Sostenibile*) (Istat 2015). The study represents a relevant contribution to the international debate on 'GDP and Beyond'.

Moreover, in 2011 Istat launched two pilot projects to deepen the measurement of BES at local level: UrBes and Provinces' BES. This paper deals with the set of indicators that have been selected and implemented by the 'Provinces' BES' Statistical Information System (SIS)<sup>7</sup> (Cuspi-Istat 2015).

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<sup>1</sup> <http://hdr.undp.org/en/statistics/hdi/>.

<sup>2</sup> <http://www.oecd.org/site/worldforum06/>.

<sup>3</sup> [http://ec.europa.eu/environment/beyond\\_gdp/background\\_en.html](http://ec.europa.eu/environment/beyond_gdp/background_en.html).

<sup>4</sup> <http://ec.europa.eu/eurostat/web/europe-2020-indicators>.

<sup>5</sup> <http://www.istat.it/visualizzazioni-statistiche/europa2020.html>.

<sup>6</sup> <http://www.istat.it/it/misure-del-benessere>.

<sup>7</sup> <http://www.besdelleprovince.it/>.

From a methodological point of view, it is well known that when the object of analysis cannot be directly observed and measured, a good collection of indicators is not sufficient to realise spatial and temporal performance comparisons. In this framework, synthesizing individual indicators into a single index, namely a composite indicator (CI), becomes an important challenge (OECD 2008; Davino and Romano 2014; Maggino 2016, 2015). Traditional approaches to the CIs' construction focus on the average effect of single indicators on the final CI, for all the units together (e.g. countries, consumers, etc.) and in an undifferentiated way for each component. Moreover, they fail to consider effects (in sign and strength of the relationships) of the extreme parts of the CI distribution.

However, a specific requirement in analyzing 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 summarizing the Province's Bes indicators this need runs into the issue of the importance given to the well-being measures, which impacts on the indicator contribution to the composite index. It then generates a trade-off between the need for synthesis and the composite responsiveness to territorial disparities.

For these reasons, we propose a hierarchical construct model for measuring the BES index at the NUTS3<sup>8</sup> level and for studying the relationships among the BES components, as BES is a multidimensional construct composed of several different domains and themes. The main methodologies involved into the paper are PLS path modeling (PLS-PM) (Wold 1985; Tenenhaus et al. 2005; Vinzi et al. 2010) and Quantile Composite-based Path Modeling (QC-PM) (Davino and Vinzi 2016; Davino 2014; Davino et al. 2016).

PLS-PM represents an important breakthrough with respect to traditional aggregation methods, such as a principal component analysis or a simple arithmetic mean of the original indicators. Instead of taking the unweighted sum of the indicators (or unit-weights for all the indicators), PLS-PM assigns weights to the original variables taking into account the network of relationships between the constructs and the variance and covariance structure within and between the blocks of variables.

Moreover, PLS-PM provides components with specific proprieties in order to enhance interpretation of the composites and the relationships among them. In particular, depending on the chosen estimation options, PLS-PM provides components that are as much correlated as possible to each other while explaining the variances of their own set of variables.

PLS-PM is a procedure based on simple and multiple ordinary least squares (OLS) regressions; it has minimal demands on measurement scales, sample size, and data distributions and it is particularly applicable for predictive applications and theory building (Chin 1998).

Quantile Composite-based Path Modeling (QC-PM) has been recently introduced (Davino and Vinzi 2016) as a complementary approach to PLS-PM. It aims to highlight if and how the relationships among observed and unobserved variables change according to

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<sup>8</sup> The acronym NUTS (from the French "Nomenclature des unités territoriales statistiques"—NUTS) stands for Nomenclature of Territorial Units for Statistics, that is the European Statistical System official classification for the territorial units. The NUTS is a partitioning of the EU territory for statistical purposes based on local administrative units. The NUTS codes for Italy have three hierarchical levels: NUTS1 (Groups of regions); NUTS2 (Regions); NUTS3(Provinces). The current NUTS 2013 classification is valid from 1 January 2015, and for Italy at the NUTS3 level it includes 110 territorial units, coinciding with the 110 provinces that existed in Italy at the reference date. During 2016, following the reform of the Local Authorities implemented by the Italian Government, some Provinces have become Metropolitan cities, while some others have been suppressed due to regional laws (in particular the Provinces of Sicily and Friuli-Venezia Giulia). As this changes have not yet been transposed into the statistical classification, in this paper, the term Provinces refers to the 110 units accounted in NUTS3, so including the new Metropolitan cities and the Provinces that no longer exist.

the explored quantile of interest, thus providing an exploration of the whole dependence structure. QC-PM is based on Quantile Regression (QR), introduced by Koenker and Basset in 1978 (Koenker and Basset 1978; Koenker 2005), which is considered as an extension of the classical least squares estimation of conditional mean models to estimate a set of conditional quantiles of a response variable as a function of a set of covariates (Davino et al. 2013). QC-PM introduces a quantile approach in the traditional PLS-PM algorithm, instead of OLS regression and, therefore, the method provides a set of model parameters for each quantile of interest.

In the present paper, PLS-PM allows us to assess the BES hierarchical model and to construct a composite indicator for BES. Since original indicators could play a different role if referred to units (Italian provinces in the proposed study) with high or low performances, the use of QC-PM is proposed to analyze relationships among variables for different parts of the BES distributions. The analysis suggests that the impacts of the domains on equitable and sustainable well-being, and the weights of the different indicators used for constructing the composites, differentiate according to the different degrees of well-being, having a different effect on provinces with high or low equitable and sustainable well-being. Such information helps decision makers to differentiate the leverages of the local policies directed to enhance living conditions in the various provinces.

This paper is organized as follows. Section 2 provides the background of the paper, including an overview of the most recent institutional debate about the measurement of well-being and its application to policies, along with a brief introduction to the projects for the measurement of well-being at the national and local levels in Italy (initiated by Istat and the Italian National Statistical System). Section 3 describes the structure of the Provinces' BES data together with some descriptive statistics. Section 4 discusses the proposed hierarchical composite model for BES and the methodology used in support of the results of the empirical analysis (which are presented in Sect. 5). Finally, Sect. 6 presents some conclusions and suggestions for future research.

## 2 Background

### 2.1 Measuring Well-Being

The debate on the measurement of societal well-being is involving ever more citizens, stakeholders, and policy makers in many countries and at different levels.

The 'Istanbul Declaration',<sup>9</sup> adopted in June 2007 by the European Commission, by the OECD, the Organization of the Islamic Conference, the United Nations, the United Nations Development Programme (UNDP), and the World Bank, is a milestone in this course, as it ratified, for the first time, a wide international agreement on 'the need to undertake the measurement of societal progress in every country, going beyond conventional economic measures such as GDP per capita'.

Afterwards, in 2009, the Communication of the European Commission (EC) titled 'GDP and beyond—Measuring progress in a changing world' stated the need to improve data and indicators to complement GDP in order to support decision making through more complete information. To achieve this goal, the EC and the Member States were required to work on five directions: (1) to complement GDP with environmental and social indicators; (2) to

<sup>9</sup> <http://www.europarl.europa.eu/sides/getDoc.do?type=REPORT&language=IT&reference=A7-0175/2011>.

provide social and environmental data information in near real-time for decision-making; (3) to provide more accurate information on social inequalities; (4) to develop a European Sustainable Development Scoreboard; (5) to extend national accounts to environmental and social issues.

The so-called ‘Stiglitz Report’, issued in 2009 by the Commission on the Measurement of Economic Performance and Social Progress (CMEPSP) (Stiglitz et al. 2009), is a further milestone. The Report underlines that ‘it has long been clear that GDP is an inadequate metric to gauge well-being over time particularly in its economic, environmental, and social dimensions, some aspects of which are often referred to as sustainability’.

With the approval, in 2010, of the ‘Sofia Memorandum’,<sup>10</sup> the European Statistical System (ESS) assumed the commitments of the EC Communication and the recommendations of the Stiglitz Report. In 2011, the ESS Committee (ESSC) adopted a report on ‘Measuring Progress, Well-being and Sustainable Development’ prepared by the Sponsorship Group, co-chaired by Eurostat and INSEE (National Statistical Institute of France).<sup>11</sup> The report summarizes 50 specific actions to be taken by the European Statistical System (ESS) to implement the commitments and the recommendations mentioned above. Eurostat reports on quality of life (OECD 2008) are the most recent advancements.

In the same year the European Commission launched the Europe 2020 strategy ‘for smart, sustainable and inclusive growth’. The EC Communication puts forward three mutually reinforcing priorities: (1) *Smart growth*: developing an economy based on knowledge and innovation; (2) *Sustainable growth*: promoting a more resource efficient, greener and more competitive economy; (3) *Inclusive growth*: fostering a high-employment economy delivering social and territorial cohesion. Collectively, these three priorities provide a clear translation of the well-being issues in terms of priorities for policy action.

## 2.2 The BES Projects: BES, UrBes, Provinces’ BES

In 2010 Istat (Italian National Statistical Institute) and Cnel (National Council for Economy and Labour) started the project to measure equitable and sustainable well-being in Italy, the BES Project, so named by the Italian acronym for Equitable and Sustainable Well-being (*Benessere Equo e Sostenibile*). The main theoretical reference of the Italian BES is the OECD framework to measure the progress of societies through the identification of its fundamental domains and dimensions (Hall et al. 2010). However, BES has a broader framework, as it is aimed to measure the fundamental aspects of the quality of life of citizens and, at the same time, to evaluate how the well-being determinants change between social groups (equity) and if the current level of well-being will be guaranteed to future generations (sustainability). Moreover, the BES project followed a participatory approach to define a common set of indicators to measure the overall progress of Italy; domains and indicators designed by the ‘Scientific committee’, were discussed and validated by a ‘Steering Committee on the extent of progress of Italian society’, including members of Istat and Cnel, and representatives from entrepreneurs, trade unions, ecological associations, councils for equal opportunities, non-governmental organisations, voluntary civic associations (Istat and Bes 2013; Sabbadini 2012a, b). In 2012, Istat and Cnel outlined the official statistical model to measure Equitable and Sustainable Well-being in Italy, determining 12 fundamental domains of BES and setting a complex of 134

<sup>10</sup> <http://ec.europa.eu/eurostat/documents/118025/118126/Sofia+memorandum+final/989e8c0a-c762-47a5-b60a-0cbce8cbbc21>.

<sup>11</sup> <http://ec.europa.eu/eurostat/web/gdp-and-beyond>.

indicators (Giovannini et al. 2012). The first BES report was published in 2013 (Istat and Bes 2013).

The BES is divided into 12 domains:

1. *Health*, which has outcomes that significantly affect life in all of its dimensions: life conditions, behaviour, social relationships, opportunities and prospects of individuals and families;
2. *Education and Training*, which provide individuals with the knowledge, abilities and skills necessary to actively participate in the society and the economy, and correlate positively to *Health*, social participation and personal satisfaction;
3. *Work and life balance*, which is related to participation in the labour market, quality of work life (both objective and subjective) and the balance between time spent working and family/social life;
4. *Economic well-being*, defined by the economic resources through which individuals and families can obtain and support specific standards of living; not only income and wealth, but also related to consumption capacity and other material aspects of living conditions;
5. *Social relationships*, which affect psychological well-being and represent a form of investment that enhances both human and social capital;
6. *Politics and institutions*, which concern civic and political participation and the trust of citizens in political institutions. This is a domain of context: correct operation of politics and institutions facilitate cooperation and social cohesion while allowing greater efficiency of public policies and a lower cost of transactions;
7. *Security*, which is the subjective perception and experience of objective personal security during daily life; as the fear of being a victim of crime can greatly affect personal freedom, the quality of life and the development of civic society overall (in the case of countries with severe security issues), this is part of the foundation of individual well-being;
8. *Subjective well-being*, as perceptions and evaluations affect the way people face life and take advantage of opportunities;
9. *Landscape and cultural heritage*, which are very important common goods that Italian public institutions are called to protect and promote, by constitutional mandate;
10. *Environment*, defined as the availability and use of natural assets and services, and the maintenance of the natural heritage in our economic systems;
11. *Research and Innovation*, which are drivers of well-being and make a fundamental contribution to smart and sustainable growth and development;
12. *Quality of services*, which are very important as the availability of services, and their use, accessibility, effectiveness, shape people and families daily life.

Predominantly, the domains of BES concern those items that have a direct impact on human and environmental well-being (outcomes) (Alkire 2012), while some others quantify the elements that underlie well-being itself (context<sup>12</sup>). The BES indicators were selected with the intent that they would at least supply a regional breakdown. However, for the most part these indicators cannot be broken down over the NUTS2 scale. Furthermore, some of the more detailed indicators are not suitable to assess the BES at the local level.

Given this reality, as local authorities began to take greater interest and involvement in the debate on well-being, Istat started two pilot projects to deepen the measurement of well-being at the local level with the cooperation of local institutions (primarily provinces

<sup>12</sup> *Politics and institutions, Research and Innovation and Quality of services.*

and municipalities): the UrBes Project (Istat and UrBes 2015),<sup>13</sup> directed to study well-being in cities and other urban areas; and the Provinces' BES project,<sup>14</sup> which focuses on Italian Provinces and Metropolitan cities.

The Provinces' BES pilot project was launched in 2011;<sup>15</sup> in 2015 it has become a current statistical source, listed in the National Statistical Programme as a Statistical Information System (SIS).

To set a dashboard of well-being measures suitable for this purpose, disaggregation of national indicators must be complemented by local indicators because information is required at both the national and focused territorial level (e-Frame 2013; Taralli 2013; Taralli and D'Andrea 2015). Therefore, Provinces' BES SIS is divided into three sections: "BES measures", "Other indicators of general relevance", "Specific indicators". The last two sections include indicators useful to assess how the local government plays a role in increasing well-being at local level; they are directly connected to the Provinces' policies and are related to one or more BES dimensions. They will no longer be considered later on in the exposure, as the paper focuses on "BES measures" at the NUTS3 level.

Focusing on the BES measures at the NUTS3 level is a useful approach both for local policies and national ones. As the OECD highlights in the 'How's Life in Your Region?' report, 'many factors that influence people's well-being are local issues, such as employment, access to health services, pollution and security; so taking into account local differences beyond national averages can improve policies' effectiveness and impact on well-being for the country as a whole' (OECD 2014).

To support evidence-based decision making and address regional policies, an overall measure of well-being is an important starting point, but to meet the policy makers' specific information needs the structure of well-being must be investigated at the local level, to emphasize specific higher or lower levels among geographical areas. From this point of view, it is very useful to appreciate the specific contribution that each component of the BES brings to the general well-being at both the local and national levels and to assess whether and how the weight of each BES determinant changes in space or varies among territorial units.

### 2.3 From the Theoretical Framework to the Structural Model

"What we measure affects what we do; and if our measurements are flawed, decisions may be distorted" (Stiglitz et al. 2009).

Specifying BES at a very detailed geographical level leads to a trade-off between information needs and data availability and it requires to deal with many others constraints, opportunities and distinctive features (Chelli et al. 2015; Taralli et al. 2015). So some considerations are useful to briefly introduce the information that was processed and the criteria that we applied to design the measurement model, in a consistent way with the theoretical framework and with our research goals.

<sup>13</sup> The UrBes project is coordinated by Istat with the collaboration of the association of Italian municipalities. In 2015 about 30 Italian municipalities took part to UrBes 2015 Report (<http://www.istat.it/urbes2015>).

<sup>14</sup> Statistical Information System of the Provinces' BES is a project promoted by the Province of Pesaro and Urbino, with the Istat's methodological and technical support. See the Italian National Statistical Programme, 2014–2016, updating to 2015 (PSU-00004). 25 Italian provinces and metropolitan cities took part in the project in 2015.

<sup>15</sup> Design study 'Analysis and evaluation of equitable and sustainable well-being of the provinces'; Italian National Statistical Programme, 2011–2013 (PSU-00003).

Although BES is a construct that has experienced significant and continuous enhancements over recent years, its indicators can't provide a comprehensive measure not even at the national level, as equity and sustainability are not methodically considered (Morrone et al. 2011; Riccardini 2015).

Compared to BES, the Provinces' BES has both more limitations and more features. At the first dataset implementation stage (2012), just 29 indicators at the NUTS3 level were equivalent to the national ones. After further developments, the database was supplemented with additional proxy indicators and some indicators were added to highlight gender or generational differences. Despite this, at the current stage BES Provinces' SIS does not satisfactorily measure the BES. The main drawback is the nearly total lack of subjective indicators at the NTUS3 level in all domains. As mentioned previously, the equity and sustainability measures are poor, and the thematic domains are not always suitably measured. As a whole, the most severe gaps affect the *Social relationships* and *Economic well-being* domains, since *Subjective well-being* is missing.

Several basic statistics were integrated in order to increase the number of the indicators: the SIS input information is provided from 37 data-sources managed by 13 different institutions. The quality of the indicators therefore varies because of the different temporal references of the data and because of the typical bias of each source (Hall et al. 2010; ESS 2001; Zaiczuk 2001). The database contains data from primary surveys (social or administrative, total or sample), statistical compilations and information systems and administrative archives processed for statistical purposes. Finally, it should be noted that these types of detailed indicators are not always sufficiently reliable, robust or relevant (Delvecchio 1995; Pintaldi 2009; Zaiczuk 2001).

Given the above mentioned issues, and considering that "what is badly defined is likely to be badly measured" (OECD 2008), we carefully assessed and selected Provinces' BES measures to build the measurement model. A theory-driven approach led us to set a consistent and properly balanced database. In order to keep only information that is of clearly demonstrable importance and that is suitable to contribute to the synthesis of the BES, in each domain just those indicators that measure direct effects or impacts on well-being (outcome indicators) have been included. In the theoretical model of the Provinces' Bes, the indicators are classified by domain, in line with the BES construct. A further classification places indicators together according to whether they pertain to the same sub-dimension (called theme) in a given domain.

In the structural model described in Fig. 2 the Provinces' BES themes<sup>16</sup> represent the first-order constructs. Provinces' BES domains<sup>17</sup> represent the second-order constructs, which are grouped into outcome and context domains at the higher level. Within the limits of the measures actually included, the structural model shows also the impacts on BES of the overall well-being level (outcome) and the framework conditions at the local level (context).

<sup>16</sup> Life expectancy, safeguard from health vulnerability, education attainment, participation in education and competencies, lifelong learning, work participation, gender gap in labor market, safety at work, political participation, institutional representation, quality of environment, restraint of resource consumption

<sup>17</sup> Health, Education and Training, Work and life balance, Economic well-being, Social relationships, Security, Landscape and cultural heritage, Environment, Research and Innovation, Politics and institutions, Quality of services.



### 3 Data

The Provinces' BES SIS covers 11 domains, each of which is further structured into two or more themes (31 themes in total). After the updated 2014 release, the SIS provided 87 indicators observed across the totality of the Italian provinces (110 units). A preliminary selection of the indicators was a theory-driven process aiming at keeping only those indicators relevant for the measurement of the BES.<sup>18</sup> The selection of the indicators from the original database was operated on the basis of the structural model described in the previous section (Sect. 2.3) and with the intent to achieve the maximum consistency with the BES theoretical framework. In fact, BES is an "emerging construct", clearly based on a formative measurement model. Therefore to measure the BES it is important to have a set of indicators suitable to capture all the well-being components, including equity and sustainability. Furthermore the elementary indicators should be all equally important from the theoretical point of view (Diamantopoulos and Winklhofer 2001; Istat 2015).

In a second step, a further assessment of the theoretical features of the retained BES measures, led to discard those less robust from a conceptual point of view. Finally, only those indicators that represent an output or an outcome with respect to the BES were included. This approach is in line with the one followed by Istat to construct the BES composites at regional level (Istat 2015). Instead, unlike Istat, in this work the composite summarizes the measures of equity and sustainability and the context domains too.

After the previous preliminary selection, a considerable pre-processing phase was executed to manage those relevant BES indicators that were not adequately reliable according to the research objectives. Furthermore, since the PLS-PM algorithm makes use of multiple regressions in its iterative process (see Sect. 4.2), the issue of multicollinearity is particularly important. For this reason, two pairs of indicators (II.6 and II.7 and III.1 and III.3) were synthesised into two single indicators (using their unweighted average, as they had the same unit of measure), as they were highly correlated with each other and therefore redundant.

Missing data related to the 7 new provinces established in Italy since 2006 were imputed according to the regional average, whereas the information to be estimated was still included in the dataset with reference to the previous administrative partition. Anyhow, the missing data imputation has involved just 7 indicators for a total of 43 cases.

The data-cleaning process and the final tuning of the data led to a data matrix comprising 40 indicators, partitioned into 11 domains and 12 themes.

Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 in the Appendix list the final domains, themes and indicators; labels in the last column will be used in graphs and tables showing the results of the study.

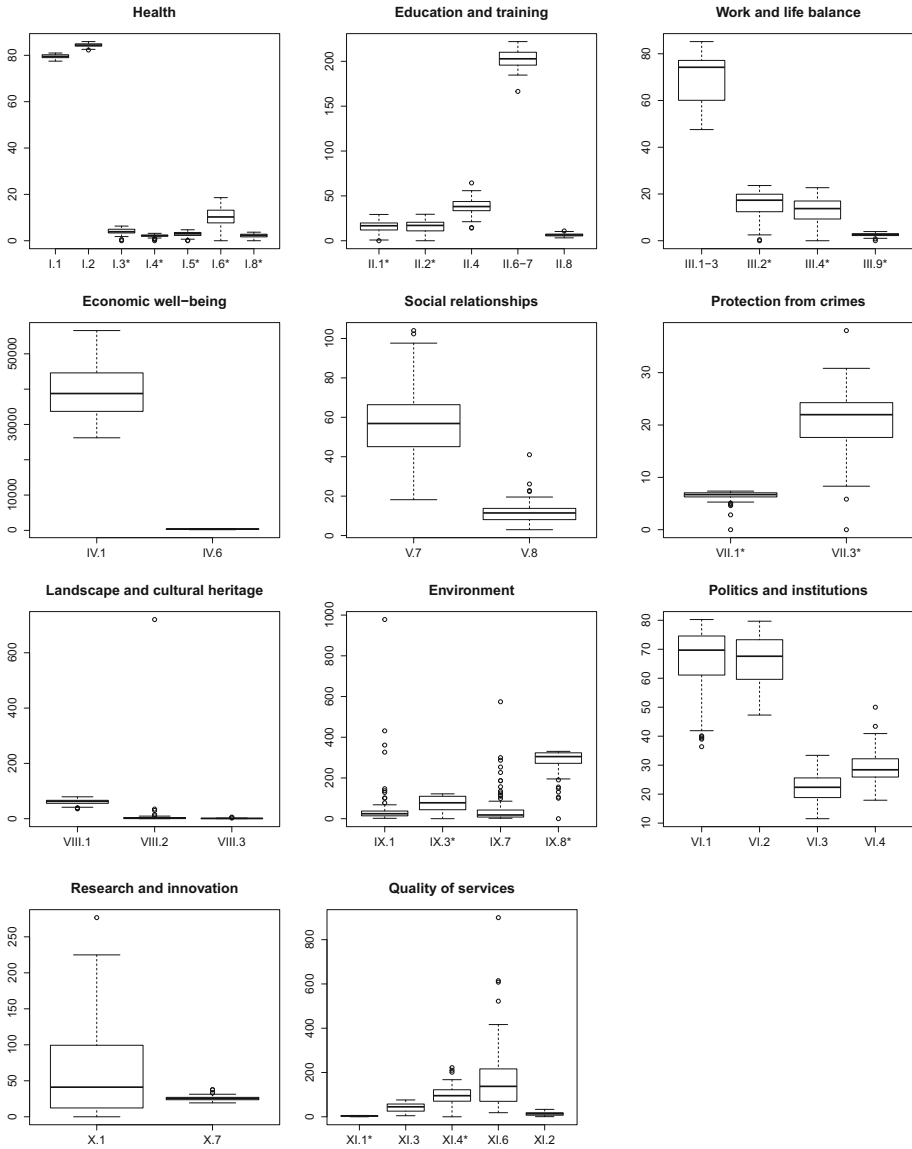
We reversed the polarity of some indicators, so that all the indicators would have the same polarity; this made easier the interpretation of the results. The asterisk symbol has been assigned to the indicators with reversed polarity.

In Fig. 1, the distributions of the indicators are shown for each block of the dataset. For the purpose of the present paper, it is worth mentioning how different the distributions of the indicators inside each block are, both in variability and skewness.

The main descriptive statistics (Table 14 in the Appendix) show differences in central tendency, variability and shape of the indicator distributions.

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<sup>18</sup> "Other indicators of general relevance" and "Specific indicators" of the Provinces' BES were excluded as pointed out in Sect. 2.2.



**Fig. 1** Multiple *boxplots* of the eleven blocks of indicators

In examining the statistics reported in Table 14 it is useful to consider that the analyzed indicators originate from various sources and therefore have different properties and a different quality depending on whether they come from primary surveys (social or administrative, total or sample), rather than statistical compilations, information systems or administrative archives processed for statistical purposes (European Statistical System 2001; Istat 2012).

Several indicators show a high variability that is worth highlighting, including *work participation* (III.I.3), which has a considerable effect on other domains and is a very

important indicator in the BES framework, and *participation in elections* (VI.1 and VI.2). *Electoral participation in parliamentary election* (VI.1) and in *provincial elections* (VI.2) are both reliable indicators because they derive from census data; it is interesting that their means are similar but that VI.1 has a much higher variability.

A multicollinearity analysis is recommended before proceeding with the parameters estimation (Albers and Hildebrandt 2006; Diamantopoulos and Winklhofer 2001). A common measure of multicollinearity is the variance inflation factor (VIF), which measures how much the variance of a regression coefficient related to a specific predictor is inflated because of linear dependence of this predictor with other predictors. As a rule of thumb, the VIF should not exceed a value of 10, but (particularly when the sample size is small) the critical value may be smaller than 10 (Hair et al. 2010). The VIF analysis has shown that the selected set of indicators is not affected by multicollinearity.

## 4 Methodological Framework

### 4.1 The Model

In this paper a hierarchical construct model for measuring and modeling the BES at the NUTS3 level is proposed. The specification of a hierarchical construct model should derive from theory that suggests how to define multidimensional constructs, the number of their sub-dimensions and the way higher-order and lower-order constructs are related to each other (Edwards 2001).

Following the available theoretical knowledge (Istat 2015), the BES data structure at the NUTS3 level is partitioned into 11 groups of variables, each one measuring a different BES domain (see Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13 in the Appendix). Moreover, a hierarchical structure can be specified, where BES is considered as a multidimensional construct at a more abstract level, composed of several different domains, each one considered separately, yet with all domains being integral parts of BES. Furthermore, in the Provinces' BES SIS, some domains are composed by more themes while others by just one theme (e.g., *Quality of services*) (Cuspi-Istat 2015).

For these reasons, we construct a hierarchical construct model, where the BES is the highest order CI and all the other domains and themes are constructs of lower order.

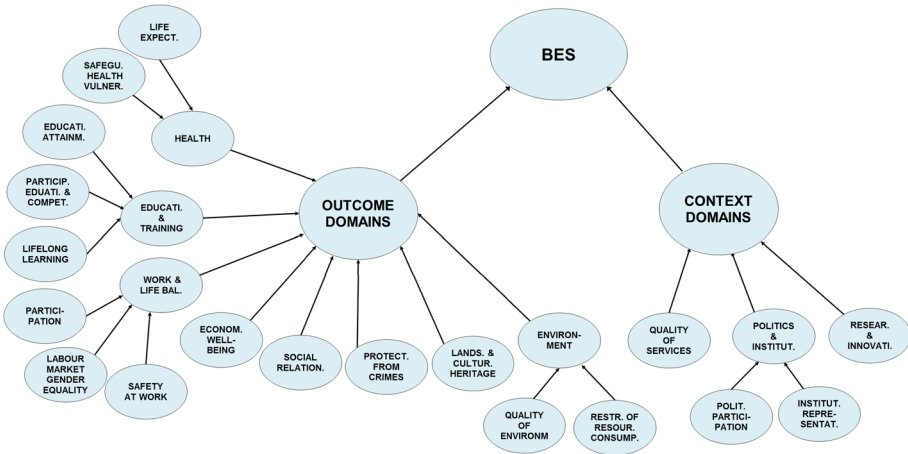
The path diagram in Fig. 2 shows the specified hierarchical structure of BES and how constructs are connected to each other. In particular, the domains that affect BES levels are grouped into two blocks: "outcome domains" and "context domains".

The former group is composed by domains<sup>19</sup> directly impacting on the BES while the latter groups those factors and elements that underline the BES and act as drivers to improve its level.<sup>20</sup> When there is more than one theme, each is considered as a separate part of a BES domain.

We use PLS-PM (Wold 1982; Tenenhaus et al. 2005) to assess what can be called a *hierarchical composite model*. Hierarchical composite modeling allows us to construct a composite indicator for BES (i.e., a global score) as well as scores for the lower-order composites (i.e., partial scores) (Guinot et al. 2001). Furthermore, we examine the

<sup>19</sup> These domains include: *Health, Education and Training, Work and life balance, Economic well-being, Social relationships, Security, Landscape and cultural heritage, Environment*.

<sup>20</sup> These domains include: *Research and Innovation, Politics and institutions, Quality of services*.



**Fig. 2** Structural model describing outcome and context domains of the Provinces’ BES

magnitude of the effects of each domain and theme on the BES, in order to search for factors mainly influencing BES.

Finally, we investigate whether relationships between composites change across different parts of the BES distributions, providing a more complete picture of the relationships between variables. This latter purpose is achieved using the Quantile Regression approach in the PLS-PM (Davino and Vinzi 2016).

### 4.2 Hierarchical Composite Model

Hierarchical composite models have recently shown an increasing popularity in PLS-PM literature, allowing researchers to extend the application to more advanced and complex path models (Becker et al. 2012; Wetzels et al. 2009).

In this paper, we use PLS-PM to assess a hierarchical composite model. PLS-PM computes a system of weights associated to each block of indicators (also named manifest variables—MVs), the so-called outer weights, by an iterative procedure, alternating an inner and an outer estimation step. In the outer estimation step, outer weights are computed and then each construct approximation is obtained as a weighted aggregate of its own MVs. Then, in the inner estimation step, each construct approximation is obtained as a weighted aggregate of the connected construct approximation. Two constructs are connected if the two corresponding blocks of MVs are linked: an arrow goes from one construct to the other in the path diagram, independently of the direction (Tenenhaus et al. 2005). These two steps are iterated until numerical convergence of the outer weights is reached.

In the PLS-PM context, constructs at a higher level can be specified as either a cause or an effect of constructs at the lower level of abstraction. Furthermore, the mode of measurement for the higher-order and lower-order composites needs to be specified (Becker et al. 2012).

We specify relationships among constructs (i.e., structural model) following the arrows direction in the path diagram in Fig. 2. A path coefficient is associated with each arrow in the network in order to show the magnitude of the relationship between the adjacent constructs (i.e., the direct impact of a lower-order construct on the corresponding higher-order construct is measured by a path coefficient).

In particular, the higher-order constructs are defined as a combination of the corresponding lower-order constructs. For example, BES is composed by ‘outcome domains’ and ‘context domains’. Higher-order composites represent common concepts that depend on several specific themes.

In order to be coherent with the causal directions specified in the structural model (Dolce et al. 2016), we define all the higher-order constructs as outwards-directed (i.e., MVs are considered as effects of the related construct), and all the first-order constructs as inwards-directed (i.e., MVs are considered as causes of the corresponding construct). Following the literature (Tenenhaus et al. 2005; Dolce and Lauro 2015), in blocks defined as outwards directed, outer weights are computed using the so-called Mode A (i.e., each MV is regressed on the corresponding instrumental construct approximation), while in blocks defined as inwards directed outer weights are computed using the so-called Mode B (i.e., weights are computed as the regression coefficients in the multiple regression of the instrumental construct approximation on its own MVs). However, it must be remembered that PLS-PM is a composite-based method. For this reason, whatever measurement scheme is applied, composites are computed as weighted aggregates of their MVs.

The most popular conceptualization of a hierarchical model using PLS-PM, the so-called repeated indicators approach, is based on repeated use of MVs (Lohmöller 1989). In other words, a higher-order construct is specified considering all the MVs of the underlying lower-order constructs. For example, a second-order construct is directly measured by the MVs related to all the first-order constructs (i.e., MVs measuring each first-order construct are repeated in order to measure the second-order construct).

Other approaches have been proposed to estimate the parameters of the hierarchical composite model (Becker et al. 2012).

The literature generally recommends the repeated indicator approach when the indicators number is balanced among the blocks, to avoid biased relationships between composites (Hair et al. 2014). However, to the best of our knowledge, there are hardly any studies in the literature that provide substantive reasons for this assumption or analyze it in detail. The simulation studies of Becker et al. (2012) show that this source of bias mainly depends on the outer mode (that is, Mode B and Mode A). In particular, the repeated indicator approach in general with Mode B does not seem to be affected by an unequal number of indicators per block.

In this study, we chose the repeated indicator approach because it considers in the estimation process all the blocks simultaneously (taking into account the whole nomological network), instead of estimating the parameters of the model and, consequently, the composite in a sequential fashion. Moreover, as said above, we use both Mode B and Mode A in our model.

### 4.3 Quantile Composite-Based Path Modeling

As mentioned above, PLS-PM is a procedure based on simple and multiple OLS regressions. For this reason, the obtained coefficients measure the rates of change in the mean of dependent variables distributions as a function of changes in a set of predictors.

However, in some particular cases, the estimates of coefficients may vary along the distribution of the dependent variable, as more than one regression coefficient describes the relationship between the dependent variable and each regressor.

This issue especially occurs in the case of heteroscedastic variances, when dependent variables are highly skewed, and in the presence of outliers. In such cases, PLS-PM may give an incomplete picture of the relationships among variables. For example, the BES

domains may have a weak or no effect on BES if we exclusively focus on changes in means, while there may be a stronger relationship considering other parts of the BES distribution. It can be interesting to evaluate if and how much the impact of each domain on BES varies among provinces with a high, medium or low level of BES, in order to discriminate among the priorities of interventions to increase the BES.

QC-PM (Davino and Vinzi 2016; Davino 2014; Davino et al. 2016) is proposed as a complementary analysis to the traditional PLS-PM, useful to distinguish different effects on the different parts of the BES distribution.

QC-PM introduces both Quantile Regression (QR) (Koenker and Basset 1978) and Quantile Correlation (QC) (Li et al. 2014) in the traditional PLS-PM algorithm. As a consequence, rather than solely estimating the conditional mean, QC-PM provides, for each quantile of interest, a set of outer weights and of path coefficients. Quantile results give a more complete picture of the relationship between variables both in the outer model (as the outer weights measure the effects of each MV on the corresponding construct) and in the inner model (as the path coefficients quantify the impact of lower-order constructs on higher order constructs).

## 5 Results

In the following section, PLS-PM results are firstly introduced to analyse average effects in the network of relationships shown in Fig. 2. An in-depth analysis is then undertaken to assess changes in the indicator influence and the impact of the BES components with changes in the BES level.

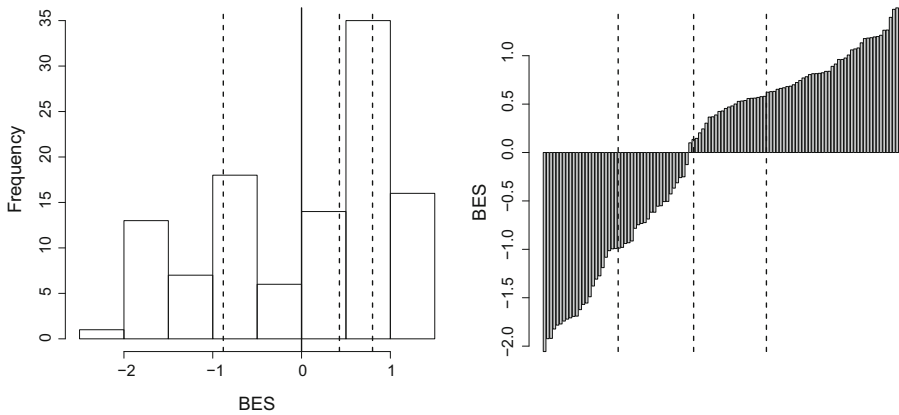
Since higher-order constructs are almost fully explained by their lower-order constructs, we only focus on the different effects of antecedent constructs on consequent constructs (i.e. path coefficients), as well as on the outer weights measuring the effects of indicators on the corresponding construct. For this reasons, we do not show any measure of fit, like the  $R^2$ , which are actually very close to 1 for each structural equation.

Results are presented and described following a top-down approach, from the BES measurement to the effects of the different indicators. In other words, with respect to the hierarchical model in Fig. 2, we start from BES and proceed to the first-order constructs up to the observed indicators.

### 5.1 PLS-PM Results

The two drivers of BES, outcome and context domains, play a different role: the normalised path coefficient of the outcome domain is equal to 0.66 while the effect of the context domain is equal to 0.34. A greater impact of the outcome was expected as outcome domains are the most complex and structured part of the model. However, PLS-PM allows a quantification of the fact that the context domain effect is half that of the outcome domain. Considering that the context domains constitute 3 of the 11 total domains, and the indicators within these 3 domains 11 of the 40 total indicators, the overall effect of the context domains is larger than the one obtained using a simple mean of indicators for constructing the composite indicators for BES and domains.

The BES distribution is highly asymmetric as shown in Fig. 3 (left-hand side) where the vertical dotted lines represent respectively the first quartile, the median and the third quartile. The left-hand and right-hand sides of Fig. 3 offer different views of the BES: the



**Fig. 3** The BES distribution (left-hand side) and the BES value for each province (right-hand side)

former is the histogram representation of the variable, while the latter depicts the BES value for each province, from the province with the lowest BES value to the highest one. Most of the provinces (59 %) register a BES value higher than the national average (PLS-PM scores are standardised). The variability in the BES conditions is higher in the remaining provinces. Moreover, the size of the BES is highly different if provinces with the lowest or the highest values are compared to those close to the average. From a tangible point of view, such a result highlights that inequalities among provinces are more stressed in provinces with a BES level below the national average.

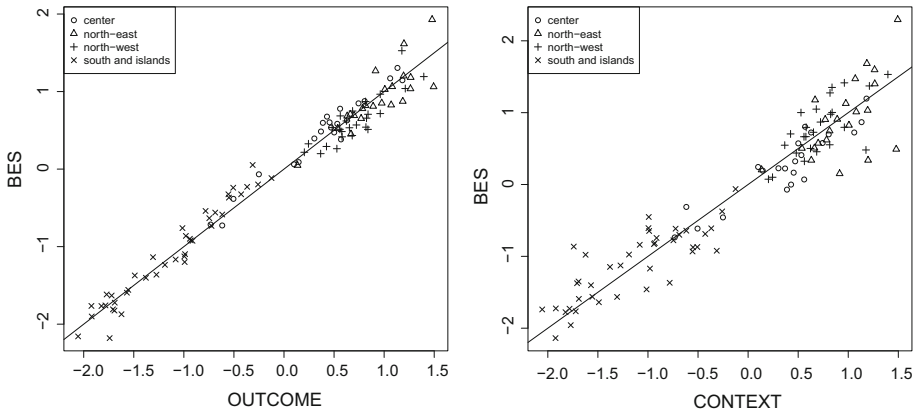
The ranking of the Italian provinces according to the BES score is provided in the Appendix (Table 15). It is worth noting that all of the provinces below the first quartile of the BES are located in the South and Insular Italy while 85 % of the provinces in the top 25 % of the BES distribution are located in the north-east or north-west area. Moving from the north to the south of the country, the global BES conditions become worse from an average point of view: 0.942 (north-east), 0.709 (north-west), 0.376 (center), -1.139 (south and islands). BES conditions are not homogeneous in the worst areas (center and south and islands) as confirmed by the highest variation coefficients: 0.338 (north-east), 0.397 (north-west), 1.357 (center), 0.468 (south and islands).

The possible rankings of the Italian provinces according to the context and the domains are quite similar (especially according to the BES rank) as shown by the values of the Spearman rank correlation coefficients (Table 1).

In the South of Italy, the context domains are more critical than the outcome domains when one takes into account the two BES drivers jointly with the geographic area (Fig. 4). In Fig. 4, the 110 provinces are plotted according to the BES and outcome values (left-

**Table 1** Spearman rank correlation coefficients between BES, outcome and context

	BES	Outcome	Context
BES		0.97	0.93
Outcome			0.84
Context			



**Fig. 4** The scatterplot of the BES against the outcome (*left-hand side*) and the context (*right-hand side*) scores according to the geographic area

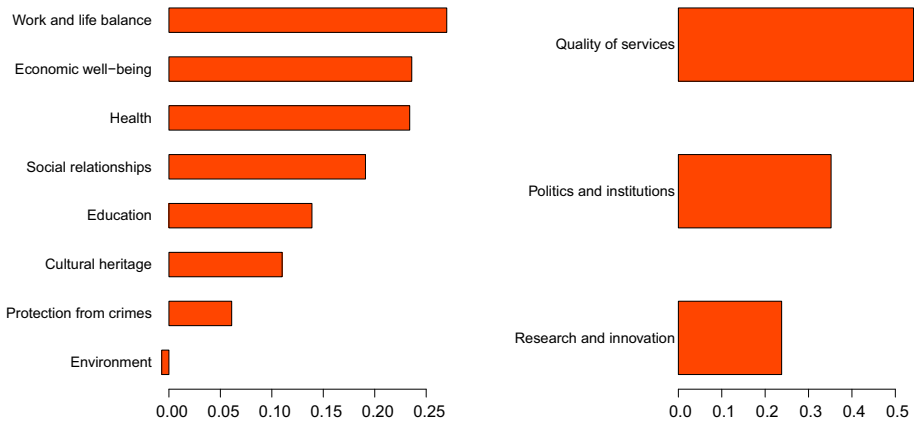
hand side) or to the BES and context values (*right-hand side*). Different symbols are used to distinguish the geographic areas of the province.

The context domains seem to be less discriminating between northern and southern provinces as compared to the outcome domains if the distributions of points below the solid line representing the equity are analysed with respect to the area. The percentages of provinces in different geographic areas with outcomes values higher than the BES were 28 % (center), 14 % (north-east), 14 % (north-west), and 43 % (south/islands). Turning to the context domains, the percentages of provinces with context values higher than the BES were 13 % (center), 18 % (north-east), 29 % (north-west), and 40 % (south/islands). The scatter plot crossing BES and context shows a higher spread around the regression line. More specifically, some southern provinces achieve a level of the BES score that is not far from some of the north-eastern provinces in spite of showing a much lower score than these provinces for the context domain.

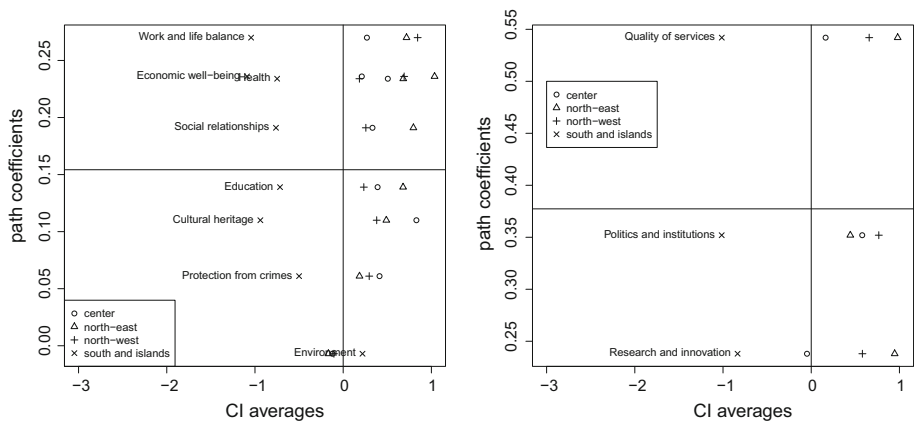
To provide an in-depth interpretation of the results we analyze the impacts of the different domains on the outcome and context drivers. The PLS-PM path coefficients (Fig. 5) are represented in decreasing order. With respect to the 8 constructs impacting the outcome (*left-hand side* of Fig. 5), it is interesting to notice to what extent the first coefficient differs from the last one: while *Work and life balance*, *Economic well-being* and *Health* have a similar importance, the role of *Cultural heritage*, *Security* and *Environment* becomes negligible. With respect to the context (*right-hand side* of Fig. 5), a central role is played by the *Quality of services*, whose importance can be considered very high (more than the double that of the *Research and Innovation* path coefficient).

The importance played by the 8 composites on the outcome domain can be jointly analysed with the composites averages according to the geographic area. Figure 6 depicts the path coefficients of each domain (vertical axis) with respect to the average of the corresponding domain; different symbols are used for each geographic area. As the set of path coefficients is the same for each area because it is estimated on the whole group of provinces, for each domain the vertical coordinate is the same. For the sake of clarity the label of each domain has been put close to the point representing the south and islands group. The plot is divided into four quadrants that can be numbered from 1 to 4 starting from the top right and counter-clockwise. A critical region is the second quadrant (top left)





**Fig. 5** The bar charts of the path coefficients for the outcome (left-hand side) and the context (right-hand side) domains



**Fig. 6** PLS-PM path coefficients with respect to composite averages for the outcome (left-hand side) and the context (right-hand side) domains

because it contains domains that have a high impact on the outcome (or on the context) but that register low average values. Looking at this critical quadrant, it is worth noticing that both for the outcome domains and for context ones, the domains resulting as the most important (higher path coefficients) register average values lower than the national average only in the Southern provinces. Low outcome values in the Southern provinces are further explained by the high disadvantage of these zones on *Work and life balance* and *Economic well-being*, which have the most relevant effect on the outcome as shown in Fig. 5. From a practical point of view, that means that in the Southern provinces decision makers should work to improve above all *Work and life balance*, *Economic well-being*, *Health* and *Social relationships* to act on the outcome domain and *Quality of services* to act on the context domain. With respect to the context, for each domain, the gap between the South of Italy and the national average is similar and always very high.

### 5.2 QC-PM Results

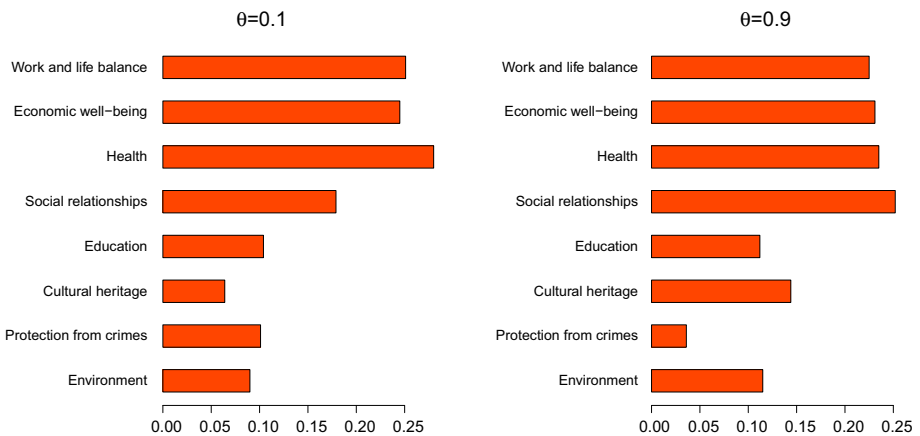
By applying a QC-PM to the model in Fig. 2 it is possible to identify for each quantile of interest the weight that each observed indicator has on the corresponding theme or domain (namely the outer weight). Moreover, for each quantile of interest we obtain an estimate of the impact of each theme on the corresponding domain as well as the impact of each domain on the BES (namely the path coefficients).

Following the top-down presentation of the results as in Sect. 5, it is interesting to compare the path coefficients of the outcome and the context using the quantile approach.

Let us consider the extreme quantiles,  $\theta = 0.1$  and  $\theta = 0.9$ . Fixing the domain order provided by the PLS-PM, it is possible to appreciate, for example, that if on average the most important domain for the outcome seems to be *Work and life balance* followed by *Economic well-being*, in the 10 % of the provinces with the lowest outcome values, *Health* is the most important factor and *Security* and the *Environment* come to light too (left-hand side in Fig. 7). Results change moving to the upper quantile where the *Social relationships* domain exceeds all the others in the importance played on the outcome (right-hand side in Fig. 7).

With respect to the context domain (Table 2), *Research and Innovation* assumes a different importance on the top (90 %) or bottom (10 %) of the context distribution.

Moving to the lower order LVs and considering a more dense grid of quantiles (0.1; 0.25; 0.5; 0.75; 0.9), a graphical representation of the path coefficients is effective in highlighting differences among PLS-PM and QC-PM results and among QC-PM coefficients at different quantiles. Figure 8 displays the trends of the path coefficients of the two constructs impacting the *Health (life expectancy and safeguard from specific health vulnerabilities)* according to the estimated quantiles.

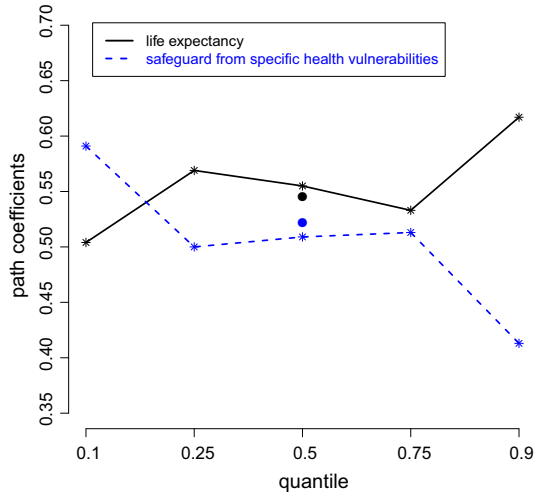


**Fig. 7** QC-PM path coefficients with respect to the extreme quantiles,  $\theta = 0.1$  and  $\theta = 0.9$

**Table 2** Path coefficients of the context domain

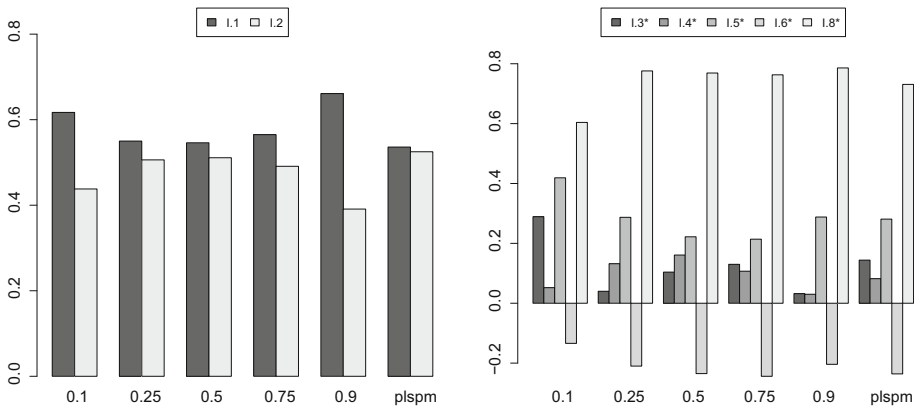
Domains	$\theta = 0.1$	$\theta = 0.9$	PLS-PM
<i>Research and Innovation</i>	0.145	0.386	0.238
<i>Political Institutions</i>	0.392	0.294	0.352
<i>Quality of services</i>	0.554	0.486	0.542

**Fig. 8** PLS-PM and QC-PM path coefficients for *Health* across a set of selected quantiles



The horizontal axis refers to each estimated quantile, the vertical axis to the corresponding coefficient. Circles refer to the path coefficients obtained from a classical PLS-PM. For the sake of easy interpretation, PLS-PM results are vertically aligned to the median regression results. Considering the path coefficients of the *Health* domain, it is worth noting that for the *life expectancy* theme, path coefficients do not vary across the distribution and with respect to the conditional mean except for the highest quantile considered. In the provinces belonging to the top 90 % of the *Health* distribution, aspects related to *life expectancy* are more important than the *safeguard from specific health vulnerabilities* whose path coefficients decrease moving from lower to upper quantiles.

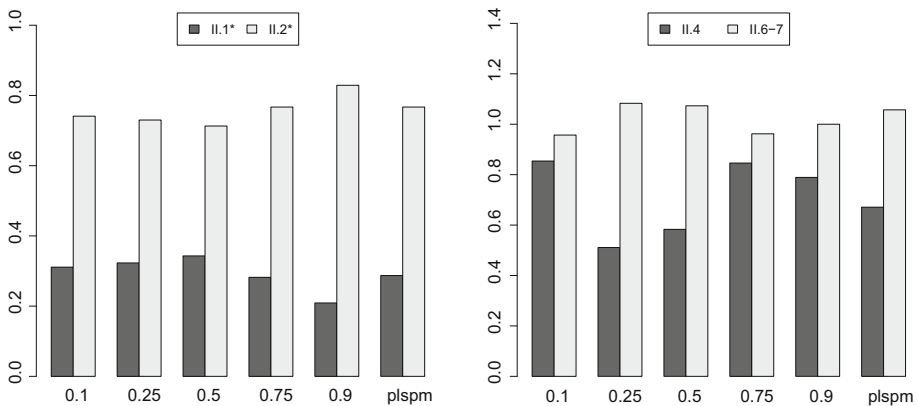
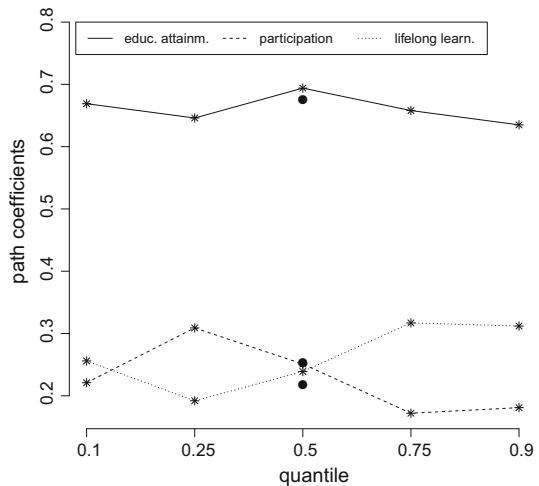
Let us consider now the weight of each indicator in constructing the corresponding theme. Differences in weight sizes can be appreciated using a graphical representation of the outer weights. The bar charts in Fig. 9 show the outer weights for the five selected quantiles and for the classical PLS-PM. For ease of interpretation, PLS-PM results are placed on the right.



**Fig. 9** PLS-PM and QC-PM outer weights for *life expectancy* and *safeguard from specific health vulnerabilities* across a set of selected quantiles

Results related to the *life expectancy at birth for men* (I.1) and *women* (I.2) (left-hand side of Fig. 9) confirm that (as women generally have higher life expectancies than men) the weight assigned to I.1 is higher on the extreme quantiles. With respect to the theme *Safeguard from specific health vulnerabilities* (right-hand side of Fig. 9), *Avoidable mortality rate* (indicator I.8) is the most important looking at the PLS-PM results, an unsurprising findings since avoidable mortality is one of the most important *Health* indicators. It includes deaths occurring to those less than 75 years old that could potentially have been avoided through population-based interventions, such as health education, through healthy lifestyles, or through preventive and curative interventions at an individual level. Moving from the lowest (0.10) to the upper quantiles, the I.8 indicator weight increases. Namely, an increment on the avoidable mortality rate has a higher effect on the higher part of the *Health* distribution. From a practical point of view, that means that where the level of BES in the *Health* domain is generally high, life expectancy is also satisfactory

**Fig. 10** PLS-PM and QC-PM path coefficients for *Education and Training* across a set of selected quantiles



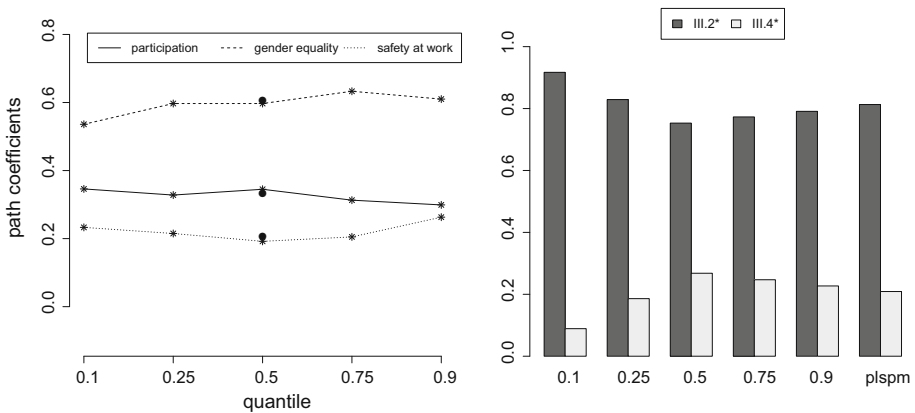
**Fig. 11** PLS-PM and QC-PM outer weights for *education attainment* (left-hand side) and *participation in education and competencies* (right-hand side) across a set of selected quantiles

and thus further improvement in *Health* for the generally healthy group measured by the domain can be achieved only working to reduce the avoidable mortality.

It is also interesting to notice that *infant mortality rate* (I.3) plays a null effect on average and across most of the composite distribution, except for the provinces with the worst health conditions (quantile 0.1). This is an example of how QC-PM results can complement PLS-PM results or even highlight information that could be hidden if the analysis were to be confined to the average effects.

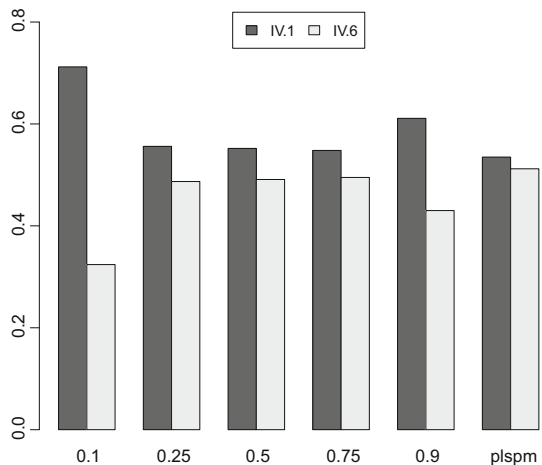
The negative effect of the indicator *mortality rate for dementia (65 years old and over)* (I.6) can be explained considering that such an indicator is strongly related to age and has an obvious negative correlation with I.8, which includes several causes of death but omits dementia.

For the sake of brevity, a complete view of the PLS-PM and QC-PM results for all the themes appear in the Appendix (Figs. 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 and 20).

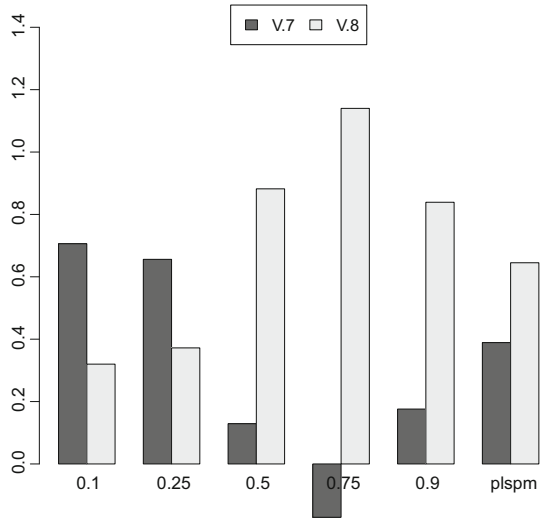


**Fig. 12** PLS-PM and QC-PM path coefficients for *Work and life balance* (left-hand side) and outer weights for *labour market gender equality* (right-hand side) across a set of selected quantiles

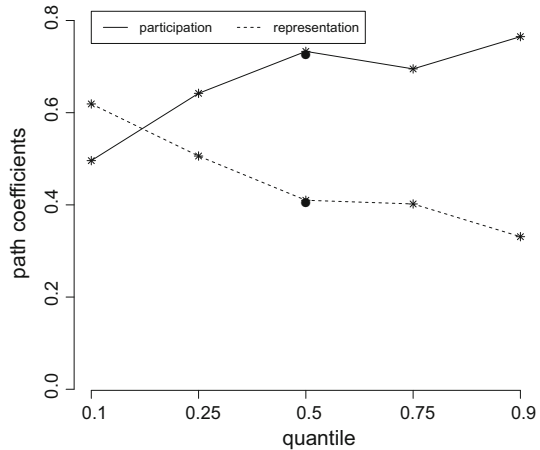
**Fig. 13** PLS-PM and QC-PM outer weights for *Economic well-being* across a set of selected quantiles



**Fig. 14** PLS-PM and QC-PM outer weights for *Social relationships* across a set of selected quantiles



**Fig. 15** PLS-PM and QC-PM path coefficients for *Politics and institutions* across a set of selected quantiles

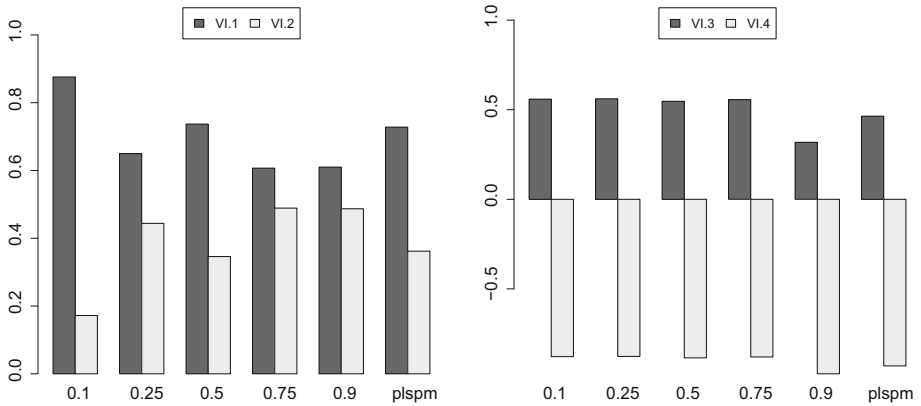


## 6 Concluding Remarks

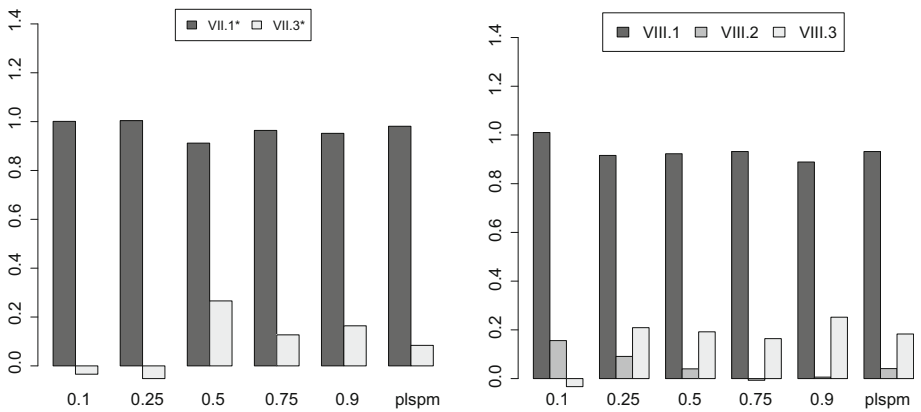
A hierarchical construct model is proposed for measuring equitable and sustainable well-being at the NUTS3 level. The model has been estimated through a consolidated methodology in the framework of multidimensional constructs, PLS-PM as well as an emerging approach based on quantile regression (QC-PM).

The main potentialities of the study can be summarized as follows:

- to measure performances by means of composite indicators for each theme, each domain and the BES as a whole;
- to synthesize different partial performances (composite indicators for each domain) into overall performances (the final BES index);
- to estimate the contribution of indicators to both partial and overall performances, conditional to different levels of the CIs;



**Fig. 16** PLS-PM and QC-PM outer weights for *political participation* (left-hand side) and *institutional representation* (right-hand side) across a set of selected quantiles



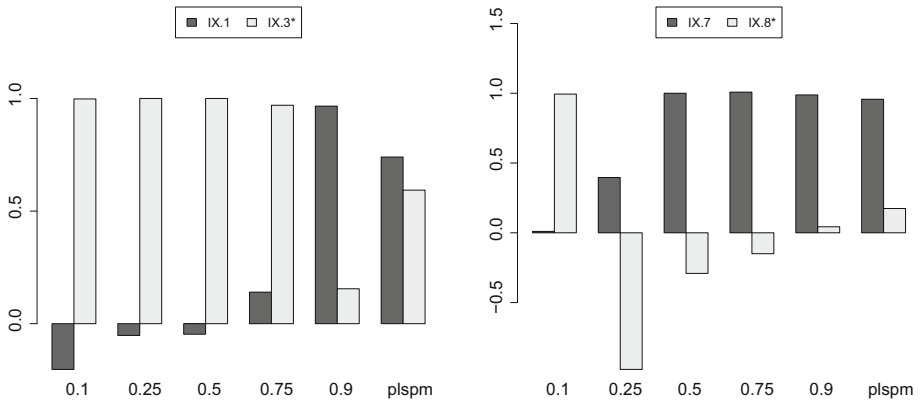
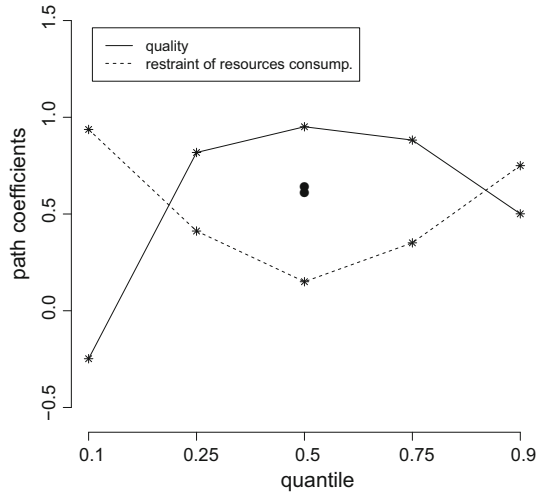
**Fig. 17** PLS-PM and QC-PM outer weights for *protection from crimes* (left-hand side) and *Landscape and cultural heritage*(right-hand side) for a set of selected quantiles

- to estimate the strength of relationships between CIs conditional to different levels of the CIs.

A quantile approach to PLS-PM is proposed to highlight differences in the impact played by the indicators and domains of the BES index, depending on the levels of equitable and sustainable well-being that characterize each area. The method is able to explore the whole distribution of the composite indicators referred to each domain and to the BES index as a whole, thus going beyond the classical investigation of the average effects. Such classical investigation has a risk of becoming misleading, especially when the average effects are not uniformly applicable to the whole distribution of the BES index, thereby obscuring specific leverages that help improve the level of the BES score locally.

The proposed analysis suggests that the impacts of the domains on equitable and sustainable well-being, and the weights of the different indicators, vary over the quantiles for some domains. This is due to the fact that these domains vary according to the different

**Fig. 18** PLS-PM and QC-PM path coefficients for *Environment* across a set of selected quantiles

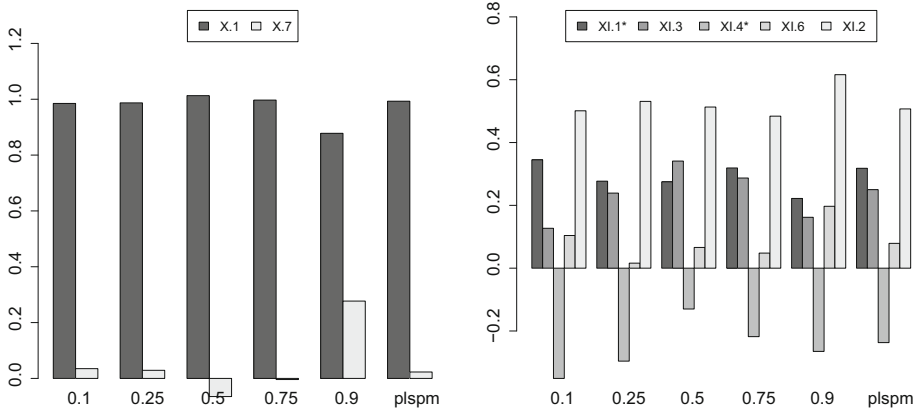


**Fig. 19** PLS-PM and QC-PM outer weights for *quality of environment* (left-hand side) and *restraint of resource consumption* (right-hand side) across a set of selected quantiles

degrees of well-being, having different effect on provinces with high or low equitable and sustainable well-being. Such information help decision makers to find out which are the critical domains in order to improve BES.

From a methodological point of view, the paper adopts the most popular conceptualization of a hierarchical model using PLS path modeling, the repeated indicators approach. For further developments, we could also compare our results using alternative approaches, which might be less affected by an unequal number of indicators per block (Becker et al. 2012; Wilson and Henseler 2007).





**Fig. 20** PLS-PM and QC-PM outer weights for *Research and Innovation* (left-hand side) and for *Quality of services* (right-hand side) across a set of selected quantiles

### Appendix

Tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 and 15.

**Table 3** Health themes and indicators

Themes	Indicator	Label
Life expectancy	Life expectancy at birth (male)	I.1
	Life expectancy at birth (female)	I.2
Safeguard from specific health vulnerabilities	Infant mortality rate	I.3*
	Mortality rate for road accidents (15–34 years old)	I.4*
	Mortality rate for cancer (20–64 years old)	I.5*
	Mortality rate for dementia (65 years old and over)	I.6*
	Avoidable mortality rate (0–74 years old)	I.8*

**Table 4** Education and Training themes and indicators

Themes	Indicator	Label
Educational attainment	Early leavers from education and training	II.1*
	People of working age with lower secondary education or less	II.2*
Participation and competencies	Participation in tertiary education (19–25 years old)	II.4
	Level of literacy and numeracy	II.6–7
Lifelong learning	Participation in lifelong learning (25–64 years old)	II.8

**Table 5** *Work and life balance* themes and indicators

Themes	Indicator	Label
Work participation	Employment rate	III.1–3
Labour market gender equality	Gender inequality in non-participation rate (M-F)	III.2*
	Gender inequality in employment rate (M-F)	III.4*
Safety at work	Incidence rate of occupational injuries, fatal or leading to permanent disability	III.9*

**Table 6** *Economic well-being* themes and indicators

Themes	Indicator	Label
Economic well-being	Gross disposable income per household	IV.1
	Households assets (total amount in average)	IV.6

**Table 7** *Social relationships* themes and indicators

Themes	Indicator	Label
Social relationships	Non-profit institutions	V.7
	Volunteers in non-profit institutions (per 100 residents aged 14+)	V.8

**Table 8** *Politics and institutions* themes and indicators

Themes	Indicator	Label
Political participation	Electoral participation (European Parliament elections)	VI.1
	Electoral participation (provincial elections)	VI.2
Institutional representation	Women and political representation in municipalities	VI.3
	Young people ( $\leq 40$ years old) and political representation in municipalities	VI.4

**Table 9** Protection from homicides and violent crimes themes and indicators

Themes	Indicator	Label
Protection from homicides and violent crimes	Homicide rate	VII.1*
	Violent crimes reported	VII.3*

**Table 10** *Landscape and cultural heritage* themes and indicators

Themes	Indicator	Label
Landscape and cultural heritage	Conservation of historic urban fabric	VIII.1
	Presence of Historic Parks/Gardens of significant public interest	VIII.2
	Museums and similar institutions	VIII.3

**Table 11** *Environment* themes and indicators

Themes	Indicator	Label
Quality of environment	Urban green areas	IX.1
	Low air pollution (PM10)	IX.3*
Restraint of resource consumption	Energy from renewable sources (electricity)	IX.7
	Restraint of Landfill storage of waste	IX.8*

**Table 12** *Research and Innovation* themes and indicators

Themes	Indicator	Label
Research and innovation	Propensity to patent	X.1
	Production industry specialization in knowledge-intensive sectors	X.7

**Table 13** *Quality of services* themes and indicators

Themes	Indicator	Label
Quality of services	Regular electricity supply	XI.1
	Separate collection of urban waste	XI.3
	No prisons exceeding capacity limits	XI.4
	Density of urban public transport networks	XI.6
	Taking charge of users for early childhood services	XI.2

**Table 14** Indicator univariate statistics

	Min	$\theta = 0.25$	Median	Mean	$\theta = 0.75$	Max	sd	Skewness
I.1	77.5	79.0	79.5	79.5	80.2	81.0	0.8	-0.1
I.2	82.3	84.0	84.4	84.4	85.0	85.9	0.8	-0.3
I.3	0.6	2.0	3.0	2.9	3.5	6.9	1.2	0.5
I.4	0.0	0.8	1.0	1.1	1.3	3.2	0.5	1.2
I.5	7.1	8.3	8.9	9.0	9.6	11.9	0.9	0.6
I.6	17.8	23.2	26.1	26.0	28.7	36.4	4.2	0.2
I.8	3.9	4.8	5.3	5.4	5.9	7.6	0.8	0.6
II.1	4.1	13.7	16.7	17.8	21.3	33.4	6.1	0.5
II.2	27.9	36.8	40.4	41.6	46.4	57.4	6.9	0.3
II.4	14.1	33.5	38.1	38.8	43.7	64.4	8.3	0.0
II.6.7	166.4	195.8	202.8	202.4	210.1	222.0	9.5	-0.5
II.8	3.2	5.4	6.5	6.5	7.4	10.9	1.5	0.4
III.1.3	47.6	60.2	74.2	68.7	77.1	85.2	10.8	-0.7
III.2	-1.0	4.8	7.3	8.7	12.2	24.6	5.3	0.9
III.4	-32.6	-23.2	-18.9	-19.8	-15.6	-9.9	5.5	-0.3
III.9	0.7	1.6	2.0	2.1	2.4	4.6	0.7	0.7
IV.1	26220.0	33810.0	38760.0	39020.0	44580.0	56590.0	6644.2	0.2

**Table 14** continued

	Min	$\theta = 0.25$	Median	Mean	$\theta = 0.75$	Max	sd	Skewness
IV.6	188.2	283.5	375.3	356.2	432.9	522.5	84.9	-0.2
V.7	18.2	45.3	56.9	57.3	66.4	104.0	15.8	0.5
V.8	3.0	8.1	11.5	11.5	13.7	41.0	5.1	2.0
VI.1	36.4	61.1	69.7	66.0	74.5	80.3	11.7	-1.0
VI.2	47.3	59.6	67.6	67.3	73.3	79.7	7.3	-0.1
VI.3	11.5	18.8	22.4	22.0	25.6	33.4	4.9	-0.2
VI.4	17.9	25.9	28.4	29.5	32.2	50.0	5.8	0.6
VII.1	0.0	0.3	0.7	0.9	1.1	7.4	0.9	3.8
VII.3	3.0	16.8	19.1	20.0	23.4	41.1	5.4	0.7
VIII.1	35.7	55.6	62.9	60.6	66.4	79.1	9.7	-0.7
VIII.2	0.0	0.5	1.7	9.6	4.2	720.2	68.5	10.3
VIII.3	0.1	0.5	0.9	1.0	1.3	5.8	0.8	2.7
IX.1	1.8	14.2	24.3	47.7	37.2	978.2	109.1	6.5
IX.3	1.0	13.0	45.0	47.6	78.8	123.0	36.2	0.4
IX.7	2.0	8.1	18.2	44.9	42.3	574.3	77.0	4.1
IX.8	0.0	7.2	25.6	44.6	58.1	330.6	56.5	2.3
X.1	0.0	12.5	41.1	62.2	98.4	276.7	60.5	1.1
X.7	19.3	23.7	25.4	25.5	26.9	37.8	3.1	1.2
XI.1	0.0	1.2	1.8	2.4	3.3	6.0	1.4	0.9
XI.3	4.8	25.5	45.0	41.0	57.5	76.0	18.6	-0.3
XI.4	6.7	106.8	133.3	131.6	157.7	228.6	38.6	-0.4
XI.6	18.5	69.9	137.4	173.3	215.9	899.6	139.2	2.1
XI.2	0.6	7.1	13.4	13.3	18.1	33.4	7.1	0.3

**Table 15** Ranking of the provinces according to the BES

Area	ID	Province	BES	Area	ID	Province	BES
North-east	BO	Bologna	1.494	North-west	GE	Genova	0.424
North-east	BZ	Provincia Autonoma Bolzano	1.479	Center	LU	Lucca	0.388
North-west	MI	Milano	1.396	Center	TR	Terni	0.369
North-east	PN	Pordenone	1.265	North-west	PV	Pavia	0.366
North-east	PR	Parma	1.263	Center	GR	Grosseto	0.303
North-west	MB	Monza e della Brianza	1.211	North-west	SP	La Spezia	0.244
North-east	TN	Provincia Autonoma Trento	1.198	North-west	IM	Imperia	0.203
North-east	RA	Ravenna	1.194	Center	RM	Roma	0.146
North-east	MO	Modena	1.186	North-east	RO	Rovigo	0.135
Center	FI	Firenze	1.182	Center	MS	Massa-Carrara	0.100
North-west	AO	Aosta	1.177	South and islands	TE	Teramo	-0.125
Center	SI	Siena	1.133	Center	RI	Rieti	-0.251

**Table 15** continued

Area	ID	Province	BES	Area	ID	Province	BES
North-east	FC	Forl-Cesena	1.080	South and islands	CH	Chieti	-0.259
North-east	RE	Reggio nell'Emilia	1.070	South and islands	AQ	L'Aquila	-0.313
Center	AN	Ancona	1.060	South and islands	PE	Pescara	-0.368
North-east	TV	Treviso	1.007	South and islands	CA	Cagliari	-0.428
North-east	PD	Padova	0.976	Center	VT	Viterbo	-0.505
North-west	BI	Biella	0.961	South and islands	IS	Isernia	-0.507
North-west	VA	Varese	0.961	South and islands	SS	Sassari	-0.550
North-east	BL	Belluno	0.914	South and islands	CB	Campobasso	-0.555
North-east	VI	Vicenza	0.890	Center	LT	Latina	-0.617
North-west	LC	Lecco	0.839	South and islands	BA	Bari	-0.617
North-west	NO	Novara	0.838	South and islands	MT	Matera	-0.687
North-west	TO	Torino	0.824	South and islands	LE	Lecce	-0.724
North-west	CR	Cremona	0.818	Center	FR	Frosinone	-0.733
North-west	CO	Como	0.815	South and islands	PZ	Potenza	-0.746
North-east	UD	Udine	0.814	South and islands	OT	Olbia-Tempio	-0.783
Center	PG	Perugia	0.805	South and islands	AV	Avellino	-0.914
North-east	VR	Verona	0.783	South and islands	BN	Benevento	-0.932
North-east	PC	Piacenza	0.770	South and islands	OR	Oristano	-0.940
Center	PU	Pesaro e Urbino	0.744	South and islands	VS	Medio Campidano	-0.980
North-west	BS	Brescia	0.723	South and islands	SA	Salerno	-0.988
North-east	RN	Rimini	0.700	South and islands	BR	Brindisi	-0.992
North-west	CN	Cuneo	0.685	South and islands	NU	Nuoro	-0.995
North-west	BG	Bergamo	0.681	South and islands	OG	Ogliastra	-1.014
north-east	FE	Ferrara	0.669	South and islands	TA	Taranto	-1.082
North-east	TS	Trieste	0.662	South and islands	CI	Carbonia-Iglesias	-1.189
North-west	MN	Mantova	0.653	South and islands	BT	Barletta-Andria-Trani	-1.274
North-east	VE	Venezia	0.631	South and islands	CZ	Catanzaro	-1.308
Center	PI	Pisa	0.629	South and islands	CS	Cosenza	-1.379
North-west	VC	Vercelli	0.623	South and islands	ME	Messina	-1.490
North-west	AL	Alessandria	0.580	South and islands	PA	Palermo	-1.555
North-west	AT	Asti	0.577	South and islands	FG	Foggia	-1.569
Center	PO	Prato	0.569	South and islands	RG	Ragusa	-1.623
North-west	SO	Sondrio	0.562	South and islands	SR	Siracusa	-1.690
Center	AR	Arezzo	0.560	South and islands	TP	Trapani	-1.693
North-west	SV	Savona	0.558	South and islands	CE	Caserta	-1.708
North-east	GO	Gorizia	0.537	South and islands	KR	Crotone	-1.721
Center	PT	Pistoia	0.532	South and islands	NA	Napoli	-1.471
North-west	LO	Lodi	0.528	South and islands	EN	Enna	-1.771
Center	LI	Livorno	0.501	South and islands	CT	Catania	-1.783
North-west	VB	Verbano-Cusio-Ossola	0.481	South and islands	RC	Reggio di Calabria	-1.823
center	FM	Fermo	0.470	South and islands	AG	Agrigento	-1.920
Center	MC	Macerata	0.455	South and islands	VV	Vibo Valentia	-1.923
Center	AP	Ascoli Piceno	0.429	South and islands	CL	Caltanissetta	-2.056

## References

- Albers, S., & Hildebrandt, L. (2006). Methodological problems in success factor studies - measurement error, formative versus reflective indicators and the choice of the structural equation model. *Zeitschrift für betriebswirtschaftliche Forschung*, 58(2), 2–33.
- Alkire, S. (2012). Dimensions of Human Development. *World Development*, 30(2), 181–205.
- Becker, J. M., Klein, K., & Wetzels, M. (2012). Hierarchical latent variable models in PLS-SEM: guidelines for using reflective-formative type models. *Long Range Planning*, 45(5), 359–394.
- Chelli, F. M., Ciommi, M., Emili, A., Gagliarano, 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*, Volume LXIX n. 3/4 Luglio-Settembre, pp. 61-73 [www.sieds.it](http://www.sieds.it).
- Chin, W. W. (1998). The partial least squares approach for structural equation modeling. In G. Marcoulides (Ed.), *Modern Methods for Business Research* (pp. 295–336). London: Lawrence Erlbaum Associates.
- Cuspi-Istat, Il benessere Equo e Sostenibile delle province. Roma, Cuspi (2015). <https://www.besdelleprovince.it/>.
- Davino C., Furno M., & Vistocco D. (2013). *Quantile Regression: Theory and Applications*. Wiley Series in Probability and Statistics, Wiley, Chichester, West Sussex.
- Davino C. (2014). Combining PLS path modeling and quantile regression for the evaluation of customer satisfaction. *Italian Journal of Applied Statistics*, 26(2) (in Press 2016).
- Davino, C., Esposito Vinzi, V., & Dolce, P. (2016). Assessment and validation in quantile composite-based path modeling. In H. Abdi, V. Esposito Vinzi, G. Russolillo, G. Saporta, & L. Trinchera (Eds.), *The multiple facets of partial least squares methods*, Springer Proceedings in Mathematics & Statistics (Chap. 13, pp. 268). New York: Springer Verlag.
- Davino, C., & Romano, R. (2014). Assessment of Composite Indicators Using the ANOVA Model Combined with Multivariate Methods. *Social Indicators Research*, 119(2), 627–646.
- Davino, C., & Vinzi, V. E. (2016). Quantile composite-based path modeling. *Advances in Data Analysis and Classification. Theory, Methods, and Applications in Data Science* doi:10.1007/s11634-015-0231-9.
- Delvecchio, F. (1995). *Scale di misura e indicatori sociali*, Bari, Cacucci.
- Diamantopoulos, A., & Winklhofer, H. M. (2001). Index construction with formative indicators: An alternative to scale development. *Journal of Marketing Research*, 38(2), 269–277.
- Dolce, P., Esposito Vinzi, V., & Lauro, C. (2016). Path directions incoherence in PLS path modeling: a prediction-oriented solution. In H. Abdi, V. Esposito Vinzi, G. Russolillo, G. Saporta, & L. Trinchera (Eds.), *The Multiple Facets of Partial Least Squares Methods*, Springer Proceedings in Mathematics & Statistics (pp. 268) New York: Springer Verlag
- Dolce, P., & Lauro, N. (2015). Comparing maximum likelihood and PLS estimates for structural equation modeling with formative blocks. *Quality & Quantity*, 49, 891–902.
- Edwards, J. R. (2001). Multidimensional constructs in organizational behavior research: an integrative analytical framework. *Organizational Research Methods*, 4(2), 144–192.
- e-Frame. (2013). European Framework for Measuring Progress, Measuring Progress at a Local level, workshop proceedings (deliverable 9.2), Pisa 25 July 2013, [www.eframeproject.eu](http://www.eframeproject.eu).
- Vinzi, V. E., Chin, W.W., Henseler J., & Wang, H. (Eds.), *Handbook of Partial Least Squares*. Springer (2010).
- European Statistical System (ESS). (2001). Summary Report from the Leadership Group (LEG) on Quality, Eurostat.
- European Statistical System. (2001). Summary Report from the Leadership Group (LEG) on Quality, Eurostat.
- Giovannini, E., Morrone, A., Rondinella, T., & Sabbadini, L. L. (2012). L'iniziativa Cnel-Istat per la misurazione del Benessere equo e sostenibile in Italia. *Autonomie locali e servizi sociali*, n. 1/2012, Il Mulino, Bologna.
- Guinot, C., Latreille, J., & Tenenhaus, M. (2001). PLS path modeling and multiple table analysis. Application to the cosmetic habits of women in Ile-de-France. *Chemometr. Intell. Lab. Syst.*, 58(2), pp. 247–259.
- Hair, J., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate Data Analysis. A Global Perspective*. USA: Pearson Education Inc.
- Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Thousand Oaks, CA: Sage.
- Hall, J., Giovannini, E., Morrone A., & Ranuzzi, G. (2010). A framework to measure the progress of societies. In *OECD Statistics Working Papers*, 2010/5, OECD Publishing.
- Istat. (2012). Linee guida per la qualità dei processi statistici.

- Istat, Bes. (2013). Il benessere equo e sostenibile in Italia, Roma, Istat.
- Istat. (2015). Il Benessere Equo e sostenibile in Italia, Roma, Istat. <http://www.misuredelbenessere.it/>.
- Istat, UrBes. (2015). Il benessere equo e sostenibile nelle città, Roma, Istat.
- Koenker, R., & Basset, G. (1978). Regression quantiles. *Econometrica*, 46, 33–50.
- Koenker, R. (2005). *Quantile regression*. Cambridge: Cambridge University Press.
- Li, G., Li, Y., & Tsai, C. (2014). Quantile correlations and quantile autoregressive modeling. *Journal of the American Statistical Association*, 110(509), 233–245.
- Lohmöller, J. B. (1989). *Latent variable path modeling with partial least squares*. Heidelberg: Physica-Verlag.
- Maggino, F. (Ed.) (2015). *A new research agenda for improvements in quality of life*. Springer International Publishing Switzerland, pp. 1–250.
- Maggino, F., & Sorvillo, M. P. (2015). Going beyond GDP: A new challenge also for training statisticians. A new Master proposal and experience. In: *New techniques and technologies for statistics*, Brussels, March 9–13, Eurostat—European Commission, pp. 1–3.
- Maggino, F. (2016). Challenges, needs and risks in defining wellbeing indicators. In: F. Maggino (Ed.) *A life devoted to quality of life* Festschrift in Honor of Alex C. Michalos, pp. 209–235, Switzerland: Springer International Publishing Switzerland.
- Morrone, A., Scrivens K., Smith C., & Balestra C. (2011). Measuring Vulnerability and Resilience in OECD Countries. In IARIW-OECD Conference on Economic Insecurity, 1964. OECD Conference Centre in Paris, France.
- OECD (2008) *Handbook on constructing composite indicators: Methodology and user guide*. Paris: OECD.
- OECD. (2014). *How's life in your region? Measuring regional and local well-being for policy making*. Paris. OECD.
- ONS. (2011). *Measuring what matters—National statistician's reflections on the national debate on measuring national well-being*.
- Pintaldi, F. (2009). *Come si analizzano i dati territoriali*. Milano: Franco Angeli.
- Riccardini F. (2015). Sustainability of wellbeing: The case of BES for Italy and SDGs Indicators. In *Paper presented at the 60° ISI conference*, Rio de Janeiro, 26–27 July, 2015.
- Sabbadini, L. L. (2012a). La nuova sfida del BES. In *Conferenza Nazionale di Statistica*, Istat, Roma.
- Sabbadini, L. L. (2012b). The path of BES: A new challenge for the measurement of quality of life. In: *ISQLS Venezia*.
- Stiglitz, J., Sen, A., & Fitoussi, J. (2009). *Report by the Commission on the Measurement of Economic Performance and Social Progress*, Paris.
- Taralli, S. (2013). Indicatori del Benessere Equo e Sostenibile delle Province: informazioni statistiche a supporto del policy-cycle e della valutazione a livello locale. *Rassegna Italiana di Valutazione*, A XVI, n. 55, Franco Angeli, Milano.
- Taralli, S., Capogrossi, C., & Perri, G. (2015). Measuring equitable and sustainable well-being (BES) for policy-making at local level (NUTS3). *Rivista Italiana di Economia Demografia e Statistica*, Volume LXIX n. 3/4, pp. 95–107, Luglio-Settembre. [www.sieds.it](http://www.sieds.it).
- Taralli, S., & D'Andrea, P. (2015). BES indicators at local level: Application to policy cycle and evaluation. In *Measuring progress at a local level*, Book of abstracts, University press, Pisa, pp. 13–16.
- Tenenhaus, M., Vinzi, V. E., Chatelin, Y. M., & Lauro, C. (2005) PLS path modeling. In *Computational statistics and data analysis*, pp. 159–205.
- Wetzels, M., Odekerken-Schröder, G., & van Oppen, C. (2009). Using PLS path modeling for assessing hierarchical construct models: Guidelines and empirical illustration. *MIS Quarterly*, 33(1), 177–195.
- Wilson, B., & Henseler, J. (2007). Modeling reflective higher-order constructs using three approaches with PLS path modeling: A Monte Carlo comparison. In *Australian and New Zealand Marketing Academy Conference* (pp. 791–800), Otago, Australia.
- Wold, H. (1982). Soft modeling: The basic design and some extensions. In K. Jöreskog & H. Wold (Eds.), *Systems under indirect observation* (Vol. 2, pp. 1–54). Amsterdam: North-Holland.
- Wold, H. (1985). Partial least squares. In S. Kotz & N. L. Johnson (Eds.), *Encyclopedia of statistical sciences*. New York: Wiley.
- Zaiczyk, F. (2001). *Il mondo degli indicatori sociali*, Carocci, Roma.