Stochastic Multiattribute Acceptability Analysis: an application to the ranking of Italian regions

Greco, Salvatore and Ishizaka, Alessio and Matarazzo, Benedetto and Torrisi, Gianpiero

22 December 2015

Stochastic Multiattribute Acceptability Analysis: an application to the ranking of Italian regions

Salvatore Greco

University of Catania, Department of Economics and Business, Corso Italia 55, 95129 Catania, Italy and University of Portsmouth, Portsmouth Business School, Centre of Operations Research and Logistics (CORL), RichmondBuilding, PortlandStreet, Portsmouth.
E-mail: salvatore.greco@port.ac.uk

Alessio Ishizaka

University of Portsmouth, PortsmouthBusinessSchool, Centre of Operations Research and Logistics (CORL), Richmond Building, Portland Street, Portsmouth, PO1 3DE, UK.
E-mail: Alessio.Ishizaka@port.ac.uk

Benedetto Matarazzo

Department of Economics and Business, University of Catania, Corso Italia 55, 95129 Catania, Italy.
E-mail: matarazz@unict.it

Gianpiero Torrisi

University of Portsmouth, Portsmouth Business School, Economics and Finance subject Group, Richmond Building, Portland Street, Portsmouth PO1 3DE, UK. E-mail: gianpiero.torrisi@port.ac.uk

Abstract. We consider the issue of ranking regions with respect to a range of economic and social variables. Departing from the current practice of aggregating different dimensions via an arithmetic mean, we instead use Stochastic Multiattribute Acceptability Analysis (SMAA). SMAA takes account of the "whole space" of weights for the considered dimensions. Thus, rather than considering an average person giving equal or fixed weights to all dimensions, SMAA explores how potential differences in individual preferences represented by different weight distributions affect the outcome. In this sense, in contrast to the purported objectivity of the many rankings supplied by economic institutions and mass media, this proposal enhances, simplifies and renders transparent the ranking exercise. The methodology is applied to the ranking of Italian regions, unveiling patterns of similarity and dissimilarity even within the same broad regional economy. Many of these findings are neglected within the extant literature addressing the "Mezzogiorno" problem.

Keywords: Stochastic Multiattribute Acceptability Analysis, Regional Development, Multiple Criteria Ranking, Composite Index.

1. **Introduction**

The measurement of regional socio-economic performance has become increasingly significant particularly in those countries characterised by persistent economic dualism such as Italy. Indeed, defining a comprehensive framework to assess regional performance is a crucial factor in both designing and evaluating regional policy. For example, with regard to the 'Cohesion policy 2014-2020' framework the classification of regions in order to assign their own eligibility status depends on their ranking in terms of GDP per head[1]. For the 2014-2020 programming period, in European Commission's words "there will be stronger result-orientation and a new performance reserve in all European Structural and Investment Funds" (European Commission, 2013b, p.3). Therefore, the focus on measuring performance at regional level would be even stronger under the new setting.

Furthermore, the issue of measuring regional performance applies to the global devolutionary trend (Rodríguez-Pose and Gill, 2003). Undeniably, the worldwide state-rescaling whose main economic argument stems from seminal contributions arguing in terms of higher efficiency (Oates, 1972; Tiebout, 1956) has enhanced the need for good quality measurement techniques. Accurate, robust, and reliable measurement techniques are crucial in order to improve the accountability and to appraise the (eventual gain in) efficiency of devolved units, especially in the current time of hard resources constraints (Great Britain, Department for Communities and Local government, 2011).

Despite the crucial importance of the indicators on the socio-economic performance for effective regional policymaking, the issue of the measurement of regional socio-economic

[1]The regions are classified in 'less developed', 'transition', and 'more developed' in order to adapt the level of support and the national contribution co-financing rate. With 'less developed' being those characterised by GDP per head lower than 75% of EU27 average; transition regions by GDP per head between 75% and 90% of EU27 average; and 'more developed' by GDP per head at least equal to 90% of EU27 average (European Commission, 2013a, p. 1).

performance is far having a clear-cut solution. This is due to several issues on both the technical and conceptual grounds. The widely used measure of economic performance are GDP or alternatively Gross Value Added (GVA)[2]. However, not to mention the general criticism about its validity as a measure of wellness dating back to 1934 (Kuznetz,1934) and more recently addressed, among others, in Kubiszewski et al. (2013), Costanza et al. (2009), and Stiglitz et al. (2009), once applied to the regional setting important additional caveats do emerge. Indeed, GDP is a good measure if the scope of the analysis is limited to the measurement of the regions' output. Nevertheless, it is not able to capture, for example, neither regions' income nor regional productivity (Dunnell, 2009). To overcome the limitations of the GDP as a measure - and subsequent ranking - of economic performance of regions, Dunnell (2009) promotes the use of GVA per hour worked and GVA per filled job as productivity measures and Gross Disposable Household Income (GDHI) per head as an indicator of the welfare of residents living in a region. Furthermore, Dunnell (2009) promotes the use of labour market indicators[3] in order to give a more complete picture of regional and subregional economic performance. Nonethless, the inability of GDP to capture the well being of economic agents is confirmed.

The Regional Competitiveness Index (RCI) (Annoni and Kozovska, 2010; Annoni, 2013) represents a more comprehensive attempt toward a single measure of regional economic attributes[4] at EU level[5]. The index builds upon the Global Competitiveness Index (GCI), published annually by the World Economic Forum (WEF) (Schwab, 2009; Schwab and Porter, 2007), and the World Competitiveness Yearbook by the Institute for Management

[2] GVA is equal to GDP plus subsidies less taxes on products. Of course, the choice between GDP and GVA does not affect comparison of regions within a country, because differences between regions are the same according to both measures.
[3] Namely, employment rates, unemployment rates and economic inactivity rates.
[4] The words 'attributes', 'characteristics', 'dimensions' and 'criteria' will be used interchangeably hereafter.
[5] The Centre for International Competitiveness computes a similar measure of regional competitiveness for both world's leading regions - World Knowledge Competitiveness Index (WKCI) (Huggins et al., 2008) - and EU-25 NUTS1 regions (Huggins and Davis, 2006). Furthermore, with reference to the UK case, it is worth recalling the most recent Huggins and Thompson (2013)'s Competitiveness Index based on Huggins (2003).

Development (IMD, 2008). The RCI aims to show strengths and weaknesses of each of the EU NUTS[6] 2 regions and considers a wide range of issues including innovation, quality of institutions, infrastructure (including digital networks) and measures of health and human capital (Dijkstra et al., 2013).

However, the weighting system is a crucial issue of any ranking (or evaluation) exercise generating a single index based on socio-economic characteristics. This controversial point stimulated a flourishing debate in the literature posing important methodological challenges. For example, w.r.t. the WEF (1999)'s methodology Lall (2001, p.98) stated

> the weighting system is *a priori;* the report says that "it was based on the economic literature", but which part of the literature yields the weights is left to imagination. Where in the literature, for instance, weight for finance as compared to technology come from? Can it be defined on economic grounds? The answers are not clear (p.1516).

The 'New GCI' (WEF, 2008) calculates weights based on a regression of the pooled dataset on country GDP per capita and test the stability of the model by reallocating individual indicators and assessing the stability of the weights and the overall score. Nonetheless, WEF (2008, p.56) notes that

> Other similar indexes have almost invariably set weights based on subjective priors based on the literature. Yet, differences in opinion in the academic literature leave the door open for different choices that can compromise the resulting rankings.

Moreover, with regard to the aforementioned RCI the Authors explicitly admit that the RCI is "*the result of a long list of subjective choices*" (Dijkstra et al., 2011, p. 16). Indeed, from a broader perspective the big issue in ranking different entities is twofold:

(i) different attributes are considered;

[6] Nomenclature of Territorial Units for Statistics

(ii) different weights for the considered attributes are used.

The latter being the most pernicious. Indeed, with respect to the possibility to consider different dimensions, it is always possible to enlarge the set of considered dimensions in order to include all the aspects being relevant for anybody interested to the ranking. However, even if two individuals could agree on the set of considered dimensions, it is very rare, or even impossible, that they could completely agree on the weights to be assigned to those dimensions, due, for example to the obvious difference in personal preferences.

Hence, should we surrender to the impossibility to get reasonable, robust, and, therefore, useful information of any ranking exercise (e.g. from ranking university to ranking countries with respect to human development index, ranking regions, or the alike)? Indeed, despite the proliferation of composite socio-economic indicators (for a review considering more than 160 different indicators see Bandura, 2008), the weights set is the manifest problem for composite indices such as, in addition to the aforementined, the popular Human Development Index (see, among others, Saisana et al. 2005; Permanyer, 2011; Cherchye et al. 2008, and Foster et al. 2009).

On this regard it is worth noticing the Organisation for Economic Co-operation and Development (OECD)'s attempt to overcome the weighting issue by presenting – rather than a single composite index – a set of nine headline indicators[7] (OECD, 2014) for 362 OECD regions. Indeed, the choice made by OECD is not to "*make a single statement about the overall well-being in a region. Instead, we [OECD] present the information in such a way that users can consider the relative importance of each topic and bring their own personal evaluations to the questions"* (OECD, 2014, p.8). Nonetheless, this choice comes with the cost of

[7] The considered dimensions are income, jobs, housing, education, health, environment, safety, civic engagement, and accessibility of services.

renouncing to a single unified view in favour of a range of indicators that is more difficult to communicate.

We argue that there is still some space for such type of ranking, but, in order to contribute, one has to take explicitly into account that one can attach different weights to considered dimensions (Helliwell, 2003; Helliwell and Barrington-Leigh, 2010). Therefore, we propose to deal with this problem adopting the Stochastic Multicriteria Acceptability Analysis (SMAA) (Lahdelma, Hokkanen and Salminen, 1988) which considers the whole set of possible weights (in fact approximated through a very large sample of randomly extracted vectors of weights). In this way, we can determine the probability with which each region is the first, the second, the third and so on in the ranking. Moreover, for each pair of regions we can define also the probability that one is better that the other or vice versa in every possible pairwise comparison. In fact, considering the whole set of possible vectors of weights, amounts to take into account all the sensibilities, ranging from the extreme ones taking into account only one or few dimensions, to the more equilibrated, taking into account all the dimensions, but in any case with different propensities. Instead, the usual approach considering a single vector of weights, *uniforms* all the individuals collapsing them to an abstract and unrealistic "representative agent".

We shall apply SMAA to the ranking of Italian regions considering with respect to socio-economic aspects. Despite the profound methodological difference[8], the present attempt is perfectly in line with the OECD initiative '*How's life in your region?*' (OECD, 2014) aiming to understand "people's level of well-being and its determinants […] to gear public policies towards better achieving society's objectives." (OECD, 2014, p. 4). In OECD (2014)'s words the rationale for the focus on the regional level is that "*many of the policies that bear most*

[8] As discussed in section 3 the OECD addressed the weighting issue by renouncing to the composite index approach in favour of a set of headline indicators.

directly on people's lives are local or regional, more fine-grained measures of well-being will help policy-makers to enhance the design and targeting of policies. They can also empower citizens to demand placed-based policy actions that respond to their specific expectations and, in turn, to restore people's trust." (OECD, 2014, p. 4).

To the best of our knowledge, this is the first time that SMAA is applied to ranking of regions for these purposes, and, more in general for ex-post ranking of entities according to their relative performance, instead of an ex-ante evaluation within a decision making process.

The paper is organised as follows. Section 2 positions the methodology with respect to the ranking of regions. Section 3 illustrates our proposal for a new ranking of Italian regions. Section 4 concludes.

2. From subjective objectivity to objective subjectivity in regional economic ranking

In Multiple Criteria Decision Aiding (MCDA) problem (Figueira et al. 2005; Ishizaka and Nemery, 2013) a set of alternatives $A=\{a_1,...,a_m\}$ is evaluated on a set of evaluation criteria $G=\{g_1,\ldots,g_n\}$ in order to deal with decision problems such as choice of the best alternative or ranking of all the alternatives from the best to the worst. For example, in regional development ranking, the alternatives are the regions of the considered country (e.g. in the case of Italy twenty regions) and the criteria are the dimension with respect to which these regions have to be evaluated (e.g. environment, cultural heritage, social capital and so on). The value function most commonly used to aggregate the evaluations of alternatives from A with respect to criteria from G is the weighted sum, which, after assigning a non-negative weight w_i to each criterion $g_i \in G$, $w_1+\ldots+w_n=1$, gives to each alternative $a_k \in A$, the following overall evaluation:

$$u(a_k, w) = \sum_{i=1}^{n} w_i g_i(a_k). \qquad \text{eq. (1)}$$

Very often one considers a simple arithmetic mean of the evaluations $g_i(a_k)$ that criteria $g_i \in G$ give to alternatives $a_k \in A$ that is to assign an equal weight to each criterion. The most natural questions in this context is: how is the ranking of an alternative a_k changing when the weights of considered criteria changes? Given two alternatives a_k and a_h from A, is it larger the set of weights w_i for which a_k is preferred to a_h or that one for which a_h is preferred to a_k?

Within MCDA these questions were addressed by the Stochastic Multiobjective Acceptability Analysis (SMAA) (Lahdelma, Hokkanen and Salminen 1988, Lahdelma and Salminen 2001; for two surveys see Tervonen and Figueira 2008 and Lahdelma and Salminen 2010). SMAA belongs to the family of MCDA methods aiming to provide recommendations on the problem at hand taking into account uncertainty or imprecision on the considered data and preference parameters.

In order to take into account imprecision with respect to the weights assigned to the considered criteria and to the evaluation taken on considered criteria, SMAA considers two probability distributions $f_W(w)$ and $f_\chi(\xi)$ on W and χ, respectively, where

$$W = \{(w_1, \ldots, w_n) \in \mathbf{R}^n : w_i \geq 0,\ i=1,\ldots n, \text{ and } w_1 + \ldots + w_n = 1\} \qquad \text{eq. (2)}$$

and χ is the evaluation space, i.e. the space of the value that can be taken by criteria $g_i \in G$.

First of all, SMAA introduces a ranking function relative to the alternative a_k:

$$rank(k, \xi, w) = 1 + \sum_{h \neq k} \rho\left(u(\xi_h, w) > u(\xi_k, w)\right), \qquad \text{eq. (3)}$$

where ρ(false) = 0 and ρ(true) = 1.

Then, for each alternative a_h, for each evaluation of alternatives $\xi \in \chi$ and for each rank $r = 1, \ldots, l$, SMAA computes the set of weights of criteria for which alternative a_k assumes rank r:

$$W_k^r(\xi) = \{w \in W : rank(k, \xi, w) = r\}\,. \qquad \text{eq. (4)}$$

SMAA is based on the computation of the following indices:

• The rank acceptability index is the relative measure (putting the measure of the set of admissible weights W equal to 1) of the set of weight vectors and evaluations on considred criteria for which the alternative a_k gets rank r:

$$b_k^r = \int_{\xi \in \chi} f_\chi(\xi) \int_{w \in W_k^r(\xi)} f_W(w)\; dw\; d\xi; \qquad \text{eq. (5)}$$

b_k^r represents the probability that alternative a_k has the *r-th* position in the preference ranking. Observe that the alternatives a_k for which $b_k^1 > 0$, i.e. the alternatives for which there exists at least one vector of weights for which they are the best, correspond to the efficient alternatives in the Data Envelope Analysis (Charnes, Cooper and Rhodes, 1987);

• The central weight vector is the barycentre of the set of weight vectors for which a_k is the best alternatives and, consequently, it represents the preferences of the average decision-maker giving to a_k the best position. It is formulated as follows:

$$w_k^c = \frac{1}{b_k^1} \int_{\xi \in \chi} f_\chi(\xi) \int_{w \in W^1(\xi)} f_W(w) w\; dw\; d\xi; \qquad \text{eq. (6)}$$

• The confidence factor gives the frequency with which an alternative is the most preferred one using its central weight vector and it is given by:

$$p_k^c = \int_{\substack{\xi \in \chi : u(\xi_k, w_k^c) \geq u(\xi_h, w_k^c) \\ \forall h=1,\ldots,l}} f_\chi(\xi)\, d\xi. \quad \text{eq. (7)}$$

Another interesting index in SMAA is the pairwise winning index (Leskinen et al., 2006), which gives the frequency that an alternative a_h is preferred or indifferent to an alternative a_k in the space of possible weight vectors and possible evaluations on single criteria:

$$p_{hk} = \int_{w \in W} f_W(w) \int_{\xi \in \chi : u(\xi_h, w) \geq u(\xi_k, w)} f_\chi(\xi) d\xi\, dw. \quad \text{eq. (8)}$$

From a computational point of view, the multidimensional integrals defining the considered indices are estimated by using the Monte Carlo method.

In our application, for the sake of simplicity, we consider a uniform probability distributions $f_W(w)$ on W, while the evaluations on considered criteria are not affected of imprecision and therefore there is not the necessity to consider the probability distribution $f_\chi(\xi)$.

In what follows we apply the SMAA technique to the ranking of Italian regions (spatial alternatives $A=\{a_1,\ldots, a_m\}$) using a set of socio-economic characteristics as evaluation criteria ($G=\{g_1,\ldots,g_n\}$) to be evaluated according to the set of weights W.

3. Application to the Italian regions ranking

We apply the aforementioned SMAA to rank the 20 Italian regions according to a set of 16 socio-economic indicators. We consider a wide range of variables taken from ISTAT[9] and

[9] For further information see http://www.istat.it/it/archivio/16777.

belonging to the ‘Territorial Database for Development Policy’ (*Banca dati territoriale per le politiche di sviluppo*). The dataset contains data collected specifically to support policy monitoring and evaluation inside the ‘Community Support Framework’ (*Quadro Comunitario di Sostegno*). Overall, it is composed by about 295 regional indices divided into ‘key contest indicators’ (*indicatori di contesto chiave)*, and ‘breaking variables’ (*variabili di rottura*). This dataset represents a powerful instrument in order to analyse structural characteristics of Italian regions. We consider the following subset of variables: environment, culture, social capital, competitiveness, energy consumption, social exclusion, per capita GDP, economic dependency, unemployment rate, crime rate, financial markets, research and development, waste treatment, IT, tourism, and care services. The reference year is 2005 as it represents the most recent year for which a balanced dataset can be extracted. Therefore, the ranking related to these variables contains a large amount of information on many aspects of regional development; one that goes well beyond the mainstream measure(s) of regional economic output (e.g. GVA or GDP). This choice is in line with the idea of the multi-dimensionality of quality of life widely accepted in the literature (Stiglitz et al., 2009; OECD, 2011)

In order to make comparable variables expressed on different metric we normalise them w.r.t. either their minimum

$$\widetilde{x_i} = \frac{x_i - x_{min}}{x_{max} - x_{min}}; \qquad \text{eq. (9)}$$

or maximum value

$$\widetilde{x_i} = \frac{x_{max} - x_i}{x_{max} - x_{min}} \qquad \text{eq. (10)}$$

depending on the variable being a direct measure of socio-economic performance (a 'good') or an inverse measure (a 'bad'), respectively. For instance, the higher the level of social exclusion, the lower the regional performance is in that respect. Therefore, social exclusion is an inverse measure of socio-economic performance to be normalised adopting the formula reported in eq. (10). Table 1 reports variables description along with summary statistics. Please note also that the last column of Table 1 reports the categorization of each variable according the aforementioned good/bad criterion.

INSERT TABLE 1 ABOUT HERE

As it is well known, Italy has a long history of economic dualism dating back to the unification process in 1861 (Del Monte and De Luzenberger, 1989; Spadavecchia, 2007; Torrisi et al. 2015). Of course, our dataset confirms such a socio-economic dualism along with the several dimensions here considered. Table 2 reports measures of concentration (Gini index) and polarization (Esteban, Gardìn, and Ray (2007) (EGR) index) for each of the 16 variables.

INSERT TABLE 2 ABOUT HERE

From Table 2 it is worth stressing that there are variables showing levels of concentration and polarization much higher than GDP (Gini index of 0.13975 and an EGR index of 0.07623). For example, the variable Economic Dependency shows a Gini index of 0.86872 and an EGR index of 0.42594. Furthermore, two key aspects - Unemployment and Social Exclusion - have both a Gini index as high as about 40% (0.41477 and 0.38883, respectively) and an EGR index of 0.22974 and 0.22696, respectively. Hence, Table 2 gives insight of the dualism involving key variables here considered. Inevitably, the resulting ranking exercise will somewhat reflect such a dualism with Northern regions generally achieving better ranks than Southern regions. Nonetheless, the SMAA approach is potentially able to unveil important aspects in this North-

South dualism contributing to answer pivotal questions for policy implementation and evaluation related to the relative performance of regions. For example, to what extent are the Northern (or Southern) regions alike? How robust is the observed dualism w.r.t. the relative importance granted to each dimension?

Despite their crucial relevance, indeed, the above questions can have only limited or no answer according to the mainstream approach based on weighted arithmetic mean of an opportune transformation of considered dimensions. This approach is followed, for example, by the EU to build the EU Regional Competitiveness Index[10] (Annoni and Kozovska, 2010; Dijkstra et al., 2011) and by the United Nations to calculate the HDI (Anand and Sen, 1997, Herrero et al., 2010). Indeed, the weighting issue is still controversial and even sophisticated attempts to achieve a common weighing framework to be applied to composite wellbeing measures have not been fully convincing (for a general discussion about the weighting issue as applied to well-being measures see, for example, Decancq and Lugo (2008)).

For the sake of illustration, we begin with the evaluation of the socio-economic performance of Italian regions according to the usual arithmetic mean (equal weights) of the performances in the considered dimensions. We call this index 'Socio-Economic Performance Index' (SEPI). Table 3 shows the resulting ranking.

INSERT TABLE 3 ABOUT HERE

As expected, Northern regions have overall a better performance than Southern ones. For example, it can be noted that Trentino Alto Adige achieves the first position in this ranking followed by Emilia Romagna, Lombardia, Veneto, and Piemonte in the top five positions. As

[10] Although we acknowledge that the cited index does perform a sensitivity analysis to test the robustness of the weighting vectors, it is worth stressing that it limits the analysis to a given interval (Dijkstra et al., 2011) with range lower or equal to 0.2 according to the development stage. Similarly, w.r.t. to the UK case, Huggins (2010) tests the robustness of the UK Competitiveness Index by means of alternative single values for the chosen weights.

for the bottom five positions, Molise ranks 16th, followed by Puglia, Calabria, Sicilia, and Campania.

Nevertheless, as already mentioned, the logic underpinning the SEPI is based on a hypothetical individual giving equal weights to all the 16 considered dimensions, without exception. Furthermore, this holds regardless of the absolute values of the considered dimensions. Therefore, for example, standardised units of ‘crime’ can be potentially exchanged with standardised units of ‘culture’ on a one-to-one basis, leaving the SEPI and resulting ranking unchanged. Since no difference in weighting has been considered for any characteristic, the score and the rank assigned in Table 3 to each region depend on the hypothesis that all the considered dimensions have equal importance. It is worth stressing that this assumption is far from being neutral. In fact, any weighting represents a precise judgment about the relative importance of each characteristic. Put differently, a weighting represents a specific point of view, even those based on equal weights. It is clear, however, that many points of view and, consequently, many types of weighting can be considered.

Nonetheless, mainstream composite indices of regional socio-economic performance do not allow for differences in the weighting system pretending being *objective*. This crucial assumption is highly debatable because, for example, different individuals might have and, indeed, they have different sensibilities w.r.t. specific dimensions. The equal weighting assumption is, in terms of local preferences, against the working of the seminal contribution related to different preferences for sets of public goods introduced with the arrival on the public finance scene of the Tiebout (1956) model and further development on fiscal federalism building upon Oates (1972) seminal contribution.

On this regard, it is worth noticing the OECD proposed to overcome the weighting issue by presenting a set of nine headline indicators[11] rather than a single composite index (OECD, 2014) for 362 OECD regions. Therefore, OECD is renouncing to a single unified view in favour of a range of indicators that is more difficult to communicate.

It is worth stressing here that the SMAA approach is able to make a substantial contribution to achieve a better balance in the debated trade-off between a composite index and a range of indicators. On the one hand, SMAA allows for the maximum of variety in the relative evaluation of each dimension of wellbeing. On the other hand, in principle it does not prevent to compute a composite index based on a set of regional characteristics.

Therefore, it seems reasonable to apply SMAA as a method offering a broader perspective to tackle the measurement of regional well-being issue. Following the SMAA approach, we considered a uniform sampling of 1,000,000 of weights vectors. Therefore, in order to take into account differences in the weighting of each characteristic concerning dimensions of regional socio-economic performance – potentially reflecting differences in preferences - we enhance the unavoidable subjectivity behind any ranking exercise by applying the SMAA approach. Table 4 reports the resulting ranking.

INSERT TABLE 4 ABOUT HERE

For the sake of clarity, rather than reporting Rank Acceptability Index (RAI), i.e. the ratio between the occurrences a region achieves a given rank and the total number of cases considered, in Table 4 we preferred to show the Rank Frequency (RF). Therefore, Table 4 reports the number of occurrences, out of the 1 million cases, a region achieves each possible ranking from 1 to 20, depending on different weights assigned to each of the 16 considered

[11] The considered dimensions are income, jobs, housing, education, health, environment, safety, civic engagement, and accessibility of services.

dimensions. Indeed, numerical approximations could assign a misleading null probability to some RAI in cases in which, even if with a small number of occurrences, RF is not null. However, when there is not the risk of these misleading conclusions, we refer to RAI rather than to RF (because, of course, RAI=RF/1,000,000). In Table 4, for example, one can see that Piemonte ranks 1st, 2nd and 3rd in 17, 1067, 22349 times out of the 1 million cases considered, respectively. Furthermore, it never ranks 12th or worse (i.e. the related RF is null).

Overall, Table 4 confirms the aforementioned North-South divide according to the wider perspective at hand. Based on a rather comprehensive set of indicators, including but not confined to GDP, and a comprehensive set of possible weights, Northern and Centre regions perform generally better than Southern regions. On this regard, it is worth stressing here three main elements. First, only Centre-Northern regions (Piemonte, Valle D'Aosta, Lombardia, Trentino Alto Adige, Veneto, Emilia Romagna, and Toscana) ranked first at least once. Second, only Southern regions (Campania, Puglia, Calabria, and Sicilia) ranked last at least once. Third, their respective best rank is as low as 16^{th}, 15^{th}, 16^{th}, and 17^{th}. Within this big picture, Sardegna represents a notable exception. Indeed, its best rank is 3rd (though in just 2 out of the million cases considered), its lowest rank is 16^{th} (in only 246 cases out of a million), and it achieves the 14^{th} rank in 641,013 cases out of the 1 million cases considered, hence, in about 64% of cases.

Although Table 4 reports the RF for all ranks, in what follows the analysis will focus on the highest RF for each region. The argument for this is that the rank related to the highest RF for each region is the rank the region achieves with the highest probability, and, therefore, with the highest level of robustness. Table 4 shows that the region with the highest RF in the first position is Trentino (with a RAI of 67.79%). Emilia Romagna achieved the highest RF in the second position (with a RAI of 61.91%). Lombardia, Veneto, and Piemonte achieved the highest rank in the third, fourth and fifth position with a RAI of 68.15%, 48.81%, and 28.72%, respectively. That is to say, in more than 2/3 of cases Trentino achieves the first position in this ranking exercise demonstrating a quite high degree of robustness to the choice of different weighting vectors. On the same premise, the data related to Emilia Romagna and Lombardia confirm that the regions achieve the second and third rank with a substantially high robustness. Furthermore, Veneto achieves the fourth position in about half of the cases considered. The datum related to the fifth position (Piemonte) is sensibly lower than the aforementioned upper positions. Nonetheless, it is about 7.5% higher than the value immediately lower in the same position (Veneto, with a RAI of 21.24%). This datum is worth 74,809 cases in which Piemonte achieves the fifth position w.r.t. Veneto.

Toscana shows a datum of similar magnitude with its highest RAI of 26.82% referring to the sixth position. The remaining positions show RAIs generally higher than 30%. Indeed, Friuli has the highest RAI equal to 38.60% in the seventh position. Valle d'Aosta in the eight with RAI of 34.78%. Both Marche and Lazio achieve their own highest RAI in the ninth position with values of 48.94% and 33.96%, respectively. Umbria achieves the eleventh position in more than half of cases (RAI of 56.52%). In contrast with the overall performance of the North-West broad region, Liguria has a robust rank in the twelfth position with RAI of 71.97%. Robust is also the rank of Abruzzo, Sardegna and Basilicata in the following three positions with RAI of 67.79%, 64.10%, and the massive 89.98%, respectively.

As far as the bottom five positions are concerned, our analysis confirms that the general wisdom concerning the Southern generalised low performance has a robust basis. Indeed, Molise, Puglia, Calabria, Sicilia, and Campania show the highest RAI in the 16th, seventeen17th, 18th, 19th, and 20th rank with RAIs of 89.92%, 84.83%, 74.42%, 63.14%, and 65.26%, respectively. Graph 1 shows the whole set of RAIs for each region.

INSERT GRAPH 1 ABOUT HERE

Building upon (Angilella et al., 2013), Table 5 reports the cumulated RAIs for each rank.

INSERT TABLE 5 ABOUT HERE

Therefore, for any rank, values in Table 5 show the probability of achieving at least that rank. For example, while Piemonte achieves a rank of 5 or above with probability 43.9%, Valle d'Aosta ranks 5 or better with probability 25.7%, Lombardia with probability 99.4%, and so on so forth.

From Table 5 it is worth noticing that 3 regions out of 20 have a probability of ranking 5 or better of (or very close to) 100%. Namely, Emilia Romagna (probability equal to 100%), Trentino Alto Adige (probability equal to 99.8%), and Lombardia (probability equal to 99.4%). Conversely, there are regions (the Northern Liguria and those from Umbria to Sardegna) with a null probability of belonging to the group of top five regions (with the very minor exception of Lazio registering a probability of 0.3%). In order to provide an even more intuitive representation of this evidence Graph 2 shows a map of the cumulated RAIs reported in Table 5.

INSERT GRAPH 2 ABOUT HERE

Once more, according to this perspective, the Italian dualism is apparent with only Northern regions having a chance to belong to the group of top five regions according to different weighting vectors. A complementary[12] Graph 3 below reports the probability of belonging to the group of bottom 5 regions.

[12] Data reported in Graph 5 come from applying the complement rule to values reported in Table 6, rank 16.

INSERT GRAPH 3 ABOUT HERE

Graph 3 while confirming from a different angle the evidence reported in Graph 2, offers interesting elements of differentiation between Southern and Islands regions. First, a white area emerges in the heart of the darkness of Southern regions competing in the Italian regional "relegation zone": it refers to the Basilicata datum (probability of only about 10%). Similarly, Abruzzo has a zero probability of belonging to the same group. Second, Sardegna shows a very low probability of belonging to the group of bottom five regions (0.02% correspondint to a RF of 246 occurrence over 1,000,000). To some extent, therefore, according to this peculiar perspective, Abruzzo, Basilicata, and Sardegna represent a kind of "Northern regions within the Southern broad region". Put differently, in a Southern broad region generally lagging behind the Northern one, Abruzzo, Basilicata and Sardegna perform generally better than the regions belonging to their broad region.

The RAI approach allows the comparison of regional performance along the cross-sectional dimension. Thus, by comparing RAIs we are able to compare the overall probability of achieving a given rank between regions. For example, as noted above, the fifth position is achieved by Piemonte in 28.72% of cases followed by Veneto that achieves the same position in 21.24% of cases. Nonetheless, RAIs fail to provide a direct comparison of the two regions. RAIs tell us that, overall, Piemonte performed better than 15 regions and worse than four other regions in 28.72% of cases. Or, in the cumulated case, the same region (Piemonte) performed at least better than 11 other regions in 100% of cases. However, neither the simple RAIs nor the cumulated ones are able to give information about the direct comparison between two regions. For example, what is the probability of Piemonte achieving a rank higher than the neighbour Lombardia? Or, with regard to the previous case, what is the probability of Piemonte achieving a rank better than Veneto?

Clearly, an answer to this kind of question is crucial in both policy design and policy evaluation as they provide information on the relative performance of potentially similar jurisdictions. In order to answer this kind of question we provide in Table 6 the Pairwise Comparison Index (PCI) for each couple of regions.

INSERT TABLE 6 ABOUT HERE

Table 6 shows the pairwise winning indices p_{hk} that gives for region a_h the probability to obtain a better score than region a_k. Thus, figures reported in each row represents relative frequencies of the region in that row achieving a score higher than regions reported in columns according to the rule '*row wins against column*'. Hence, regarding the previously mentioned direct comparison Piemonte vs Lombardia, Piemonte achieved a better score than Lombardia in only about 2% of cases. Of course, symmetrically Lombardia performed better than Piemonte in about 98% of cases. The last column of Table 6 reporting the Average PCI (APCI) aims to provide a synthetic measure of the overall performance of each region with respect to other region. Thus for a region a_k , the corresponding APCI, denoted q_k, is given by the arithmetic mean of the PCI p_{kh} of region a_k with respect to other regions a_h, that is

$$q_k = \frac{\sum_{h \neq k} p_{hk}}{n-1}. \qquad \text{eq. (11)}$$

Of course, the APCI ranges from zero (i.e. the region achieves a lower score than the remaining 19 in all cases considered) to 1 (i.e. the region achieves a better score than all the "opponents" in all cases). Therefore, Trentino Alto Adige (APCI of 98%) and Emilia Romagna (APCI of 96%) confirm to be "champions" also according to this perspective. On the other edge, Campania with an APCI of only 2% confirms all its weakness in this context. Furthermore, in terms of North-South divide, Table 6 shows that from Molise to Sicilia in no occurrence a

Southern region achieves a better score than regions belonging to the Centre-North broad region. Noteworthy, while Liguria loses the direct comparison with all the Centre-North regions from Piemonte to Lazio (PCI w.r.t. to Umbria and Lazio is 1% and 3%, respectively), Sardegna has a better performance than the Southern Molise, Campania, Puglia, Basilicata, Calabria, and Sicilia in all the cases here considered.

For the sake of conciseness, we do not analyse all the pairwise comparisons reported in Table 6. Nonetheless, it is worth stressing here that our approach allowing the direct comparison of pairs of regions unveils patterns of both similarity and dissimilarity even within the same broad region. In so doing, it makes a substantial contribution aiming to go a step further the already widely researched North-South divide.

4. Concluding remarks

We applied the SMAA technique to the ranking of Italian regions according to a set of socio-economic indicators including but not confined to GDP. To the best of our knowledge, this is the first attempt to explore differences in local development using such an approach permitting to take into consideration different preferences of different class of individuals corresponding to different weight vectors. In the Italian regional context characterised by a strong and persistent dualism this exercise has two main features. First, it allows for a validation of computational results based on prior knowledge of both quantitative and qualitative aspects the Italian regions built over decades of research involving the *questione meridionale* (Southern question). Second, it is able to unveil patterns of spatial disparities more articulated than the already widely researched North-South divide. For example, our analysis finds clear-cut and robust evidence (i) of a generalised better performance of Sardegna w.r.t. the other big island (Sicilia) and, overall, w.r.t. the Southern broad region, and (ii) of a generalised lower performance of Liguria as compared to the Northern broad region. Indeed, the latter result concerning the poor performance of Liguria is in line with the extant literature comparing the relative endowment of infrastructure of Italian regions to assess levels of corruption (Golden and Picci, 2005) and has been explained in terms of orography. However, our ranking exercise does not rely on physical infrastructure endowment. Therefore, the explanation in terms of orography is not convincing and our analysis opens new issues regarding Liguria's relative performance. More generally, the reasons behind our results undoubtedly raise interesting and challenging questions able to influence the debate between both academics and policy-makers.

Furthermore, the implementation of more advanced techniques to unveil and enhance the subjectivity involved in any ranking of territorial units is left to the future research agenda, also considering more advanced models permitting to take into consideration other related aspects such as interaction between criteria (Angilella, Corrente and Greco 2015) and hierarchy of criteria (Angilella, Corrente, Greco and Slowinski 2015). Nonetheless, our exploratory analysis demonstrates that the SMAA approach - potentially applicable to cross-national comparisons – is able to make a substantial contribution to achieve a robust evaluation of the relative socio-economic performance moving from subjective objectivity toward objective subjectivity.

References

Anand, S., & Sen, A. (1997). Concepts Or Human Development And Poverty! A Multidimensional Perspective. *United Nations De-velopment Programme, Poverty and humandevelopment: Human development papers*, 1-20.

Angilella, S., Bottero, M., Corrente, S., Ferretti, V., Greco, S., & Lami, I. M. (2013). Non Additive Robust Ordinal Regression for urban and territorial planning: an application for siting an urban waste landfill. *Annals of Operations Research*, 1-30.

Angilella, S., Corrente, S., Greco, S. (2015). Stochastic multiobjective acceptability analysis for the Choquet integral preference model and the scale construction problem. *European Journal of Operational Research*, *240*(1), 172-182.

Angilella, S., et al. "Robust Ordinal Regression and Stochastic Multiobjective Acceptability Analysis in multiple criteria hierarchy process for the Choquet integral preference model." Omega. In Press. doi:10.1016/j.omega.2015.10.010

Annoni, P. (2013). EU Regional Competitiveness Index (RCI 2013). Publications Office.

Annoni, P., Kozovska, K. (2010). EU regional competitiveness index. *Luxembourg, European Commission*.

Bandura, R. (2008). "A survey of composite indices measuring country performance: 2008 update." Office of Development Studies.

Charnes, A., W. Cooper, and E., Rhodes "Measuring the efficiency of decision-making units," European Journal of Operational Research 2, 429–444, 1987.

Cherchye, L., Moesen, W., Rogge, N., Van Puyenbroeck, T., Saisana, M., Saltelli, A., Liska, R., Tarantola, S. (2008). Creating composite indicators with DEA and robustness analysis: the case of the Technology Achievement Index. *Journal of the Operational Research Society*, *59*(2), 239-251.

Costanza, R., Hart, M., Posner, S., Talberth, J. (2009). Beyond GDP: The Need for New Measures of Progress. Pardee Paper No. 4, Boston: Pardee Center for the Study of the Longer-Range Future.

Decanq, K., & Lugo, M. A. (2009). Setting Weights in Multidimensional Indices of Well-being and Deprivation. *Document de travail de l'OPHI*, (18).

Del Monte, A. and R. De Luzenberger (1989). The Effect of Regional Policy on New Firm Formation in Southern Italy. *Regional Studies*, 23(3), 219-230.

Dijkstra, L., Annoni, P., and K. Kozovska. (2011). A New Regional Competitiveness Index: Theory, Methods and Findings, Working Paper 2/2011. Brussels: European Commission.

Dunnell, K. (2009). National Statistician's article: Measuring regional economic performance. *Economic and Labour Market Review*, 3(1), 18–30

Esteban, J., Gradin, C., & Ray, D. (1999). Extension of a Measure of Polarization, with an Application to the Income Distribution of Five OECD Countries," Papers 24, El Instituto de Estudios Economicos de Galicia Pedro Barrie de la Maza.

European Commission. (2013a). *One trillion euro to invest in Europe's future – the EU's budget framework 2014-2020*. Brussels: European Commission.

European Commission. (2013b). *Refocusing EU Cohesion Policy for Maximum Impact on Growth and Jobs: The Reform in 10 points*. Brussels: European Commission.

Great Britain. Department for Communities and Local Government. (2007). Decentralisation outcomes: a review of evidence and analysis of international data. London: DCLG.

Foster, J., McGillivray, M., & Seth, S. (2009). Rank robustness of composite indices. *OPHI Working paper 26*.

Helliwell, J. F. (2003). "How's life? Combining individual and national variables to explain subjective well-being." Economic Modelling.

Helliwell, J. F., & Barrington-Leigh, C. P. (2010). Viewpoint: Measuring and understanding subjective well-being. *Canadian Journal of Economics/Revue canadienne d'économique*, *43*(3), 729-753.

Herrero, C., Martínez, R., and Villar, A. (2010). Multidimensional social evaluation: an application to the measurement of human development. *Review of Income and Wealth*, *56*(3), 483-497.

Huggins, R. (2003). Creating a UK Competitiveness Index: regional and local benchmarking. *Regional Studies*, 37(1), 89-96.

Huggins, R., Davies, W. (2006). European Competitiveness Index 2006-07. Cardiff: University of Wales Institute, Robert Huggins Associates Ltd.

Huggins, R., Izushi, H. (2008). UK Competitiveness Index 2008. University of Wales Institute. Cardiff: Centre for International Competitiveness, Cardiff School of Management.

Huggins, R., Izushi, H., Davies, W., and L. Shougui. (2008). World Knowledge Competitiveness Index. Cardiff: Centre for International Competitiveness.

Huggins, R., and P. Thompson. (2010). UK competitiveness index 2010. Cardiff: Centre for International Competitiveness, UWIC.

Huggins, R., and P. Thompson. (2013). UK competitiveness index 2010. Cardiff: Centre for International Competitiveness, UWIC.

IMD (2008). World Competitiveness Yearbook 2008. Lausanne: Institute for Management Development.

Ishizaka, A. and P. Nemery (2013). Multi-criteria Decision Analysis: Methods and Software, Wiley.

Kubiszewski, I., Costanza, R., Franco, C., Lawn, P., Talberth, J., Jackson, T., and C. Aylmer. (2013). Beyond GDP: Measuring and achieving global genuine progress. Ecological Economics 93: 57-68.

R. Lahdelma, J. Hokkanen, and P. Salminen. SMAA - Stochastic Multiobjective Acceptability Analysis. European Journal of Operational Research, 106(1):137–143, 1998.

R. Lahdelma and P. Salminen. SMAA-2: Stochastic Multicriteria Acceptability Analysis for group decision making. Operations Research, 49(3):444–454, 2001.

Lahdelma R, Salminen P. Stochastic multicriteria acceptability analysis (SMAA). In: Ehrgott M, Figueira J, Greco S, editors. Trends in Multiple Criteria Decision Analysis. New York: Springer; 2010. p 321–354

Lall, S. (2001). Competitiveness indices and developing countries: an economic evaluation of the global competitiveness report. *World Development*, 29(9), 1501–1525.

Monte, A. D., & Luzenberger, R. D. (1989). The effect of regional policy on new firm formation in Southern Italy. *Regional Studies*, *23*(3), 219-230.

OECD (2011). *How's Life?: Measuring Well-Being*. Paris: OECD Publishing.

OECD (2014). *How's Life in Your Region?: Measuring Regional and Local Well-being for Policy Making*. Paris: OECD Publishing.

P. Leskinen, J. Viitanen, A. Kangas, and J. Kangas. Alternatives to incorporate uncertainty and risk attitude in multicriteria evaluation of forest plans. Forest Science, 52(3):304–312, 2006.

Oates, W. E. (1972). *Fiscal federalism*. New York, Harcourt Brace Jovanovich.

Permanyer, I. (2011). Assessing the robustness of composite indices rankings. *Review of Income and Wealth*, *57*(2), 306-326.

Golden, M. A., & Picci, L. (2005). Proposal for a new measure of corruption, illustrated with Italian data. *Economics & Politics*, *17*(1), 37-75.

Rodríguez-Pose, A., & Gill, N. (2003). The global trend towards devolution and its implications. *Environment and Planning C: Government and Policy*, 21(3), 333–351.

Saisana, M., Saltelli, A., & Tarantola, S. (2005). Uncertainty and sensitivity analysis techniques as tools for the quality assessment of composite indicators. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, *168*(2), 307-323.

Schwab, K. and Porter, M. E. (2007). The Global Competitiveness Report 2007-2008. World Geneva: Economic Forum.

Schwab, K. (2009). The Global Competitiveness Report 2009-2010. Geneva: World Economic Forum.

Schwab K. (2014). The Global Competitiveness Report 2014–2015. Geneva: World Economic Forum.

Spadavecchia, A. (2007). "Regional and national industrial policies in Italy, 1950s–1993. Where did the subsidies flow?" University of Reading Working Paper No. 48.

Stiglitz, J., Sen, A., & Fitoussi, J. P. (2009). The measurement of economic performance and social progress revisited. *Reflections and overview. Commission on the Measurement of Economic Performance and Social Progress, Paris*.

T. Tervonen and J.R. Figueira. A survey on stochastic multicriteria acceptability analysis methods. Journal of Multi-Criteria Decision Analysis, 15(1-2):1–14, 2008.

T. Tervonen, J.R. Figueira, R. Lahdelma, and P. Salminen. SMAA-III: A simulation-based approach for sensitivity analysis of ELECTRE III. In: Real-Time and Deliberative Decision Making, pages 241–253. Springer, 2009.

Tiebout, C. M. (1956). A pure theory of local expenditures. *The journal of political economy*, 416-424.

Torrisi, G., Pike, A., Tomaney, J., & Tselios, V. (2015). (Re-)exploring the link between decentralization and regional disparities in Italy. *Regional Studies, Regional Science*, *2*(1), 122–139.

WEF (1999). Schwab, K., Porter, M. E., Sachs, J. D. , Warner, A. M., and Levinson M. (Eds.), The global competitiveness report 1999. New York: Oxford University Press for World Economic Forum.

Table 1 – Variables descriptive statistics

Variable	Description	Mean	SD	Min	Max	Categorisation
Environment	Woodland (hectares)	523376.8	306122.1	105928	1213250	Good
Culture	Share of Household Expenditure on Culture on total household expenditure	6.8	.8397995	5.6	8.4	Good
Social Capital	Volunteering. People aged 14 and over who have done volunteer work in the total population aged 14 and over	11.575	4.983011	6.3	27.7	Good
Competitiveness	Capital accumulation. Gross fixed capital formation as a percentage of GDP	21.895	2.964612	17.6	30.4	Good
Energy	Gross domestic consumption of electricity. Gross production of electricity plus the balance of trade with other countries and with other regions (GWh)	.0062734	.0016783	.003451	.0095629	Good
Social exclusion	Relative poverty index. Share of population living in households below the poverty line (percent)	13.07	9.771823	9.771823	34.5	Bad
GDP	GDP per capita	23792.65	6000.588	15516	32672	Good
Economic Dependency	Net import share on GDP	8.28	12.94111	-12.4	33	Bad
Unemployment	Unemployment rate (long term)	3.875	3.006637	.6	9.4	Bad
Crime conditions	Violent crimes per capita	16.66	5.423089	11.2	36.6	Bad
R&D	R&D employees (per capita)	2.62	1.245455	.9	5.8	Good
Waste treatment	Recycling rate on total households waste	21.4	14.03447	5.2	47.7	Good
Care Services	Children 0-3 years who have used the services for children (kindergarten, crèche, or supplementary and innovative services)	12.3	9.203832	1.9	40.3	Good
IT	Proportion of people aged 6 and over who report having used the Internet in the last three months	30.13	5.001378	20.7	37.5	Good
Tourism	Attractiveness of tourism facilities. Presences (days) in the total accommodation establishments	8.5	9.411695	2.3	41.5	Good
Financial Markets	Investment (expansion e replacement) as a percentage of GDP	.0246	.0425891	0	.187	Good

Note: all variables refer to year 2005. Variables categorised as 'Good' have been normalised according to the formula $\frac{x_i - x_{min}}{x_{max} - x_{min}}$. Variables categorised as 'Bad' have been normalised according to the formula $\frac{x_{max} - x_i}{x_{max} - x_{min}}$. Source: authors' elaboration on ISTAT (various years).

Table 2 – Disparities in socio-economic indicators

Variable	Gini	EGR
Environment	0.30876	0.01407
Culture	0.06875	0.03422
Social Capital	0.21194	0.11269
Competitiveness	0.07055	0.03085
Energy	0.14737	0.07045
Social exclusion	0.38883	0.22696
GDP	0.13975	0.07623
Economic Dependency	0.86872	0.42594
Unemployment	0.41477	0.22974
Crime conditions	0.14328	0.06489
R&D	0.25553	0.12276
Waste treatment	0.35813	0.18918
Care Services	0.37146	0.16745
IT	0.08943	0.04495
Tourism	0.45635	0.2301
Financial Markets	0.69207	0.4015

Source: authors' elaboration on ISTAT (various years)

Table 3 – Socio-Economic Performance Index (SEPI)

Region	SEPI	Rank
Piemonte	0.572575	5
Valle d'Aosta	0.5442875	8
Lombardia	0.6198499	3
Trentino-Alto Adige	0.71105	1
Veneto	0.597575	4
Friuli-Venezia Giulia	0.5600813	7
Liguria	0.4096	12
Emilia-Romagna	0.6781563	2
Toscana	0.5662313	6
Umbria	0.45525	11
Marche	0.47765	9
Lazio	0.4736125	10
Abruzzo	0.3817812	13
Molise	0.2500062	16
Campania	0.1108875	20
Puglia	0.190325	17
Basilicata	0.27425	15
Calabria	0.1613187	18
Sicilia	0.1258812	19
Sardegna	0.365475	14

Notes: Regional Socio-Economic Performance Index (SEPI) based on the arithmetic mean of normalised indicators reported in Table 1. Source: authors' elaboration on ISTAT (various years).

Table 4- Rank Frequency

Rank	PI	VA	LO	TR	VE	FR	LI	ER	TO	UM	MA	LA	AB	MO	CM	PU	BA	CA	SI	SA
1	17	288	1719	677919	6	0	0	320051	1	0	0	0	0	0	0	0	0	0	0	0
2	1067	15408	87215	258042	18320	147	0	619059	736	0	0	5	0	0	0	0	0	0	0	0
3	22349	67916	681490	50052	111260	2855	0	41999	21971	0	0	106	0	0	0	0	0	0	0	2
4	128215	58801	180969	8373	488080	27868	0	16046	90584	0	1	1062	0	0	0	0	0	0	0	2
5	287224	114651	42832	3768	212415	151666	0	2437	183123	0	23	1861	0	0	0	0	0	0	0	3
6	243387	89142	5413	1314	128724	258257	0	391	268160	0	176	5019	0	0	0	0	0	0	0	16
7	184229	127112	327	414	30415	385969	0	13	257159	0	2073	12244	0	0	0	0	0	0	0	43
8	124848	347765	35	110	9737	169390	0	4	174453	374	60452	112059	0	0	0	0	0	0	0	772
9	8252	111475	0	7	1040	3840	5	0	3805	33646	489362	339569	1	0	0	0	0	0	0	8999
10	400	40019	0	1	3	8	363	0	7	386040	344863	217588	17	0	0	0	0	0	0	10690
11	12	22279	0	0	0	0	31181	0	1	565188	91501	256532	2501	0	0	0	2	0	0	30803
12	0	3873	0	0	0	0	719681	0	0	14665	11358	44567	66202	0	0	0	20	0	0	139635
13	0	833	0	0	0	0	150063	0	0	87	186	6992	677888	0	0	0	116	0	0	163836
14	0	423	0	0	0	0	97686	0	0	0	5	2293	253390	352	0	0	4836	0	0	641013
15	0	15	0	0	0	0	959	0	0	0	0	102	1	98211	0	2	896770	0	0	3940
16	0	0	0	0	0	0	60	0	0	0	0	1	0	899151	45	1719	98233	545	0	246
17	0	0	0	0	0	0	2	0	0	0	0	0	0	2223	1682	848268	23	147796	6	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	56	70234	144859	0	744205	40646	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	7	275472	5075	0	88010	631436	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	652567	77	0	19444	327912	0

Note: the table reports the number of cases out of the 1 million cases generated by different weights sets in which each region achieves a given rank from 1 to 20. Source: authors’ elaboration on ISTAT (various years).

Table 5 – Cumulated Rank Acceptability Index

	Rank																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Piemonte	0.000	0.001	0.023	0.152	0.439	0.682	0.866	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Valle d'Aosta	0.000	0.016	0.084	0.142	0.257	0.346	0.473	0.821	0.933	0.973	0.995	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lombardia	0.002	0.089	0.770	0.951	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Trentino-Alto Adige	0.678	0.936	0.986	0.994	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Veneto	0.000	0.018	0.130	0.618	0.830	0.959	0.989	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Friuli-Venezia Giulia	0.000	0.000	0.003	0.031	0.183	0.441	0.827	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Liguria	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.032	0.751	0.901	0.999	1.000	1.000	1.000	1.000	1.000	1.000
Emilia-Romagna	0.320	0.939	0.981	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Toscana	0.000	0.001	0.023	0.113	0.296	0.565	0.822	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Umbria	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.034	0.420	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Marche	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.063	0.552	0.897	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Lazio	0.000	0.000	0.000	0.001	0.003	0.008	0.020	0.132	0.472	0.690	0.946	0.991	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Abruzzo	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.069	0.747	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Molise	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.099	0.998	1.000	1.000	1.000	1.000
Campania	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.072	0.347	1.000
Puglia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.850	0.995	1.000	1.000
Basilicata	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.902	1.000	1.000	1.000	1.000	1.000
Calabria	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.148	0.893	0.981	1.000
Sicilia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.041	0.672	1.000
Sardegna	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.010	0.021	0.051	0.191	0.355	0.996	1.000	1.000	1.000	1.000	1.000	1.000

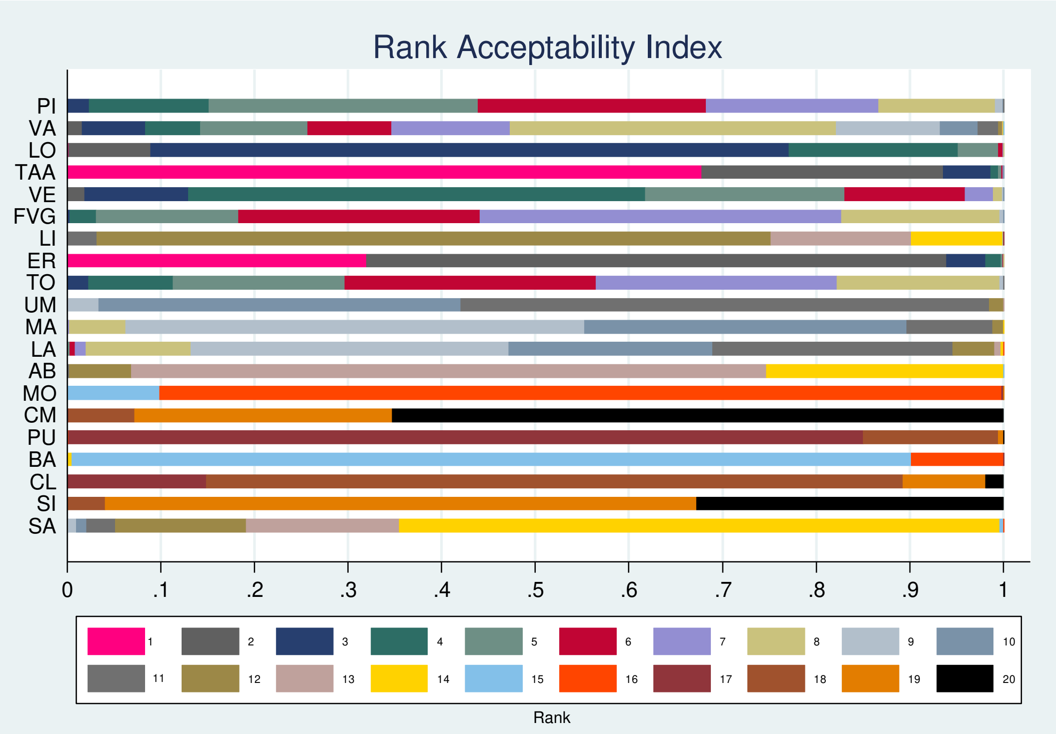
Notes: the table reports the cumulated frequency of RAI reported in Table 4. Source: authors' elaboration on ISTAT.

Table 6 - Pairwise Comparison Index

	PI	VA	LO	TA	VE	FR	LI	ER	TO	UM	MA	LA	AB	MO	CM	PU	BA	CL	SI	SA	Average
PI	1	0.67	0.02	0.01	0.21	0.65	1	0	0.61	1	1	0.99	1	1	1	1	1	1	1	1	0.74
VA	0.33	1	0.09	0	0.16	0.37	1	0.02	0.35	0.97	0.9	0.86	1	1	1	1	1	1	1	1	0.69
LO	0.98	0.91	1	0.06	0.86	0.99	1	0.04	0.97	1	1	1	1	1	1	1	1	1	1	1	0.88
TA	0.99	1	0.94	1	0.99	1	1	0.68	1	1	1	1	1	1	1	1	1	1	1	1	0.98
VE	0.79	0.84	0.14	0.01	1	0.93	1	0.03	0.81	1	1	0.99	1	1	1	1	1	1	1	1	0.82
FR	0.35	0.63	0.01	0	0.07	1	1	0	0.44	1	1	0.99	1	1	1	1	1	1	1	1	0.71
LI	0	0	0	0	0	0	1	0	0	0.01	0	0.03	0.85	1	1	1	1	1	1	0.79	0.40
ER	1	0.98	0.96	0.32	0.97	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.96
TO	0.39	0.65	0.03	0	0.19	0.56	1	0	1	1	1	0.99	1	1	1	1	1	1	1	1	0.73
UM	0	0.03	0	0	0	0	0.99	0	0	1	0.12	0.32	1	1	1	1	1	1	1	0.98	0.50
MA	0	0.1	0	0	0	0	1	0	0	0.88	1	0.54	1	1	1	1	1	1	1	0.98	0.55
LA	0.01	0.14	0	0	0.01	0.01	0.97	0	0.01	0.68	0.46	1	0.99	1	1	1	1	1	1	0.96	0.54
AB	0	0	0	0	0	0	0.15	0	0	0	0	0.01	1	1	1	1	1	1	1	0.66	0.36
MO	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0.1	1	1	0	0.22
CM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.01	0	0.07	0.34	0	0.02
PU	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.99	1	0	0.85	1	0	0.15
BA	0	0	0	0	0	0	0	0	0	0	0	0	0	0.9	1	1	1	1	1	0	0.26
CL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.93	0.15	0	1	0.95	0	0.11
SI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.66	0	0	0.05	1	0	0.04
SA	0	0	0	0	0	0	0.21	0	0	0.02	0.02	0.04	0.34	1	1	1	1	1	1	1	0.35

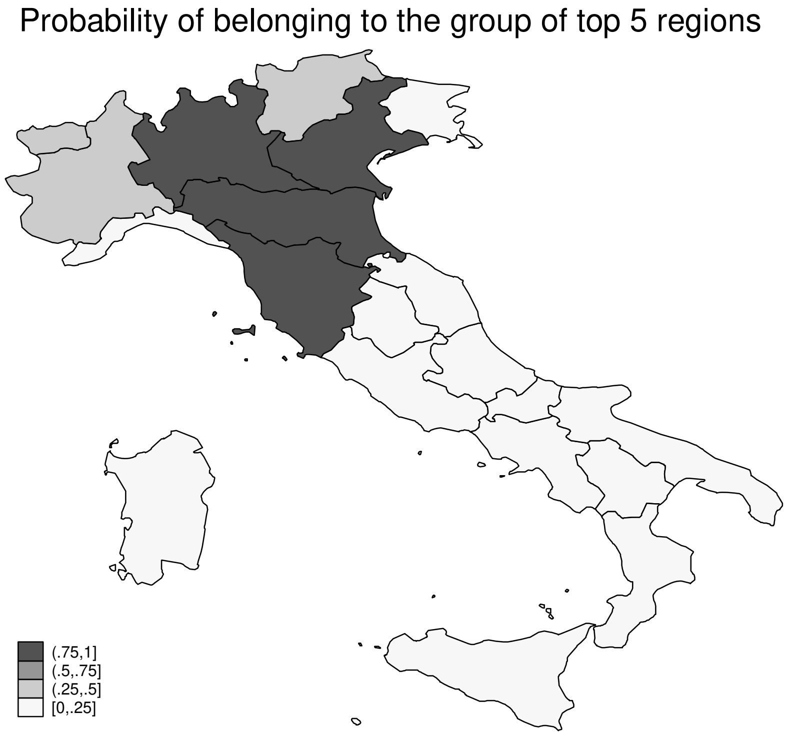
Source: authors' elaboration on ISTAT (various years).

Graph 1 – Rank Acceptability Index



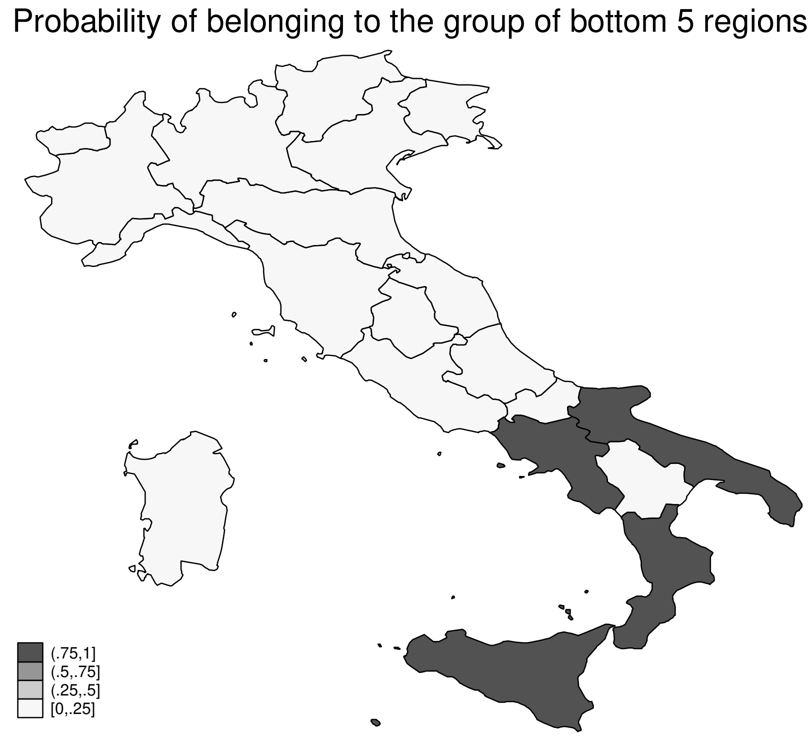
Source: authors' elaboration on ISTAT.

Graph 2 – Probability of belonging to the group of top five regions



Source: authors' elaboration on ISTAT

Graph 3 – Probability of belonging to the group of bottom five regions



Source: authors' elaboration on ISTAT