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The Europe 2020 Regional Index

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Executive Summary

In this report we develop a composite index to measure regional progress towards meeting key objectives set forth by Europe 2020[1], the European Commission's ten year growth strategy launched in March 2010. The work presented is part of a broader Administrative Arrangement between DG REGIO and DG JRC, N 2013. CE.26.BA T. 069, whose aim was to develop a set of regional composite indicators covering dimensions of well-being and development. Its results are planned to be included in DG REGIO's Sixth Cohesion Report, scheduled for publication in June 2014.

Europe 2020 consists of a set of goals involving employment, education, poverty, research and development (R&D), and environmental sustainability. These goals were quantified via European-wide numerical targets on a group of relevant economic, social, and environmental indicators. To accommodate the heterogeneity of EU-28 countries, the European-wide objectives were transformed into a set of more realistic national targets for individual countries. This was done for a majority of country-indicator pairs (by the member countries themselves).

To obtain a spatially refined appreciation of Europe 2020's current status and the future challenges underlying its successful implementation, the composite indicator we develop is disaggregated to the regional NUTS 2 level. This posed a number of challenges regarding data availability, primarily with regard to the environmental sustainability and poverty objectives. Sometimes these challenges could be addressed, and sometimes not. In particular, as there is no regional data whatsoever for the environmental sustainability indicators, we decided to drop them from the composite index. Meanwhile, we were able to keep poverty and social exclusion indicators in the index by employing sensible imputation techniques where necessary.

We propose a straightforward methodology for the calculation of the Regional Europe

[1] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

2020 Index, that can be easily applied and understood. The approach we adopt is similar to the one used in the computation of the Lisbon Index (Dijkstra, 2010). A region's progress towards meeting an individual goal is measured via the (appropriately normalized) shortfall of its actual performance with respect to its national Europe 2020 target. Subsequently, its Europe 2020 Index score is calculated by considering a weighted arithmetic average of these percentage shortfalls over the set of all indicators. The weighting scheme we employ assigns equal weight to the objectives of employment, research and development, education, and poverty and social exclusion.

Top-10	**Bottom-10**
Vlaams-Brabant - BE24*	Ciudad Autónoma de Ceuta - ES63
Praha - CZ01*	Ciudad Autónoma de Melilla - ES64
Oberbayern - DE21	Canarias - ES70
Bratislavský kraj - SK01	Sicilia - ITG1
Helsinki-Uusimaa - FI1B	Andalucía - ES61
Trento - ITH2	Extremadura - ES43
Vastverige – SE23	Región de Murcia - ES62
Emilia-Romagna - ITH5	Campania - ITF3
Stockholm - SE11	Castilla-La Mancha - ES42
Dresden – DED2	Região Autónoma dos Açores –PT20

Top and Bottom-10 performing regions in Europe 2020 Regional Index (listed in descending and ascending order, respectively). An asterisk denotes regions that meet or exceed all their targets.

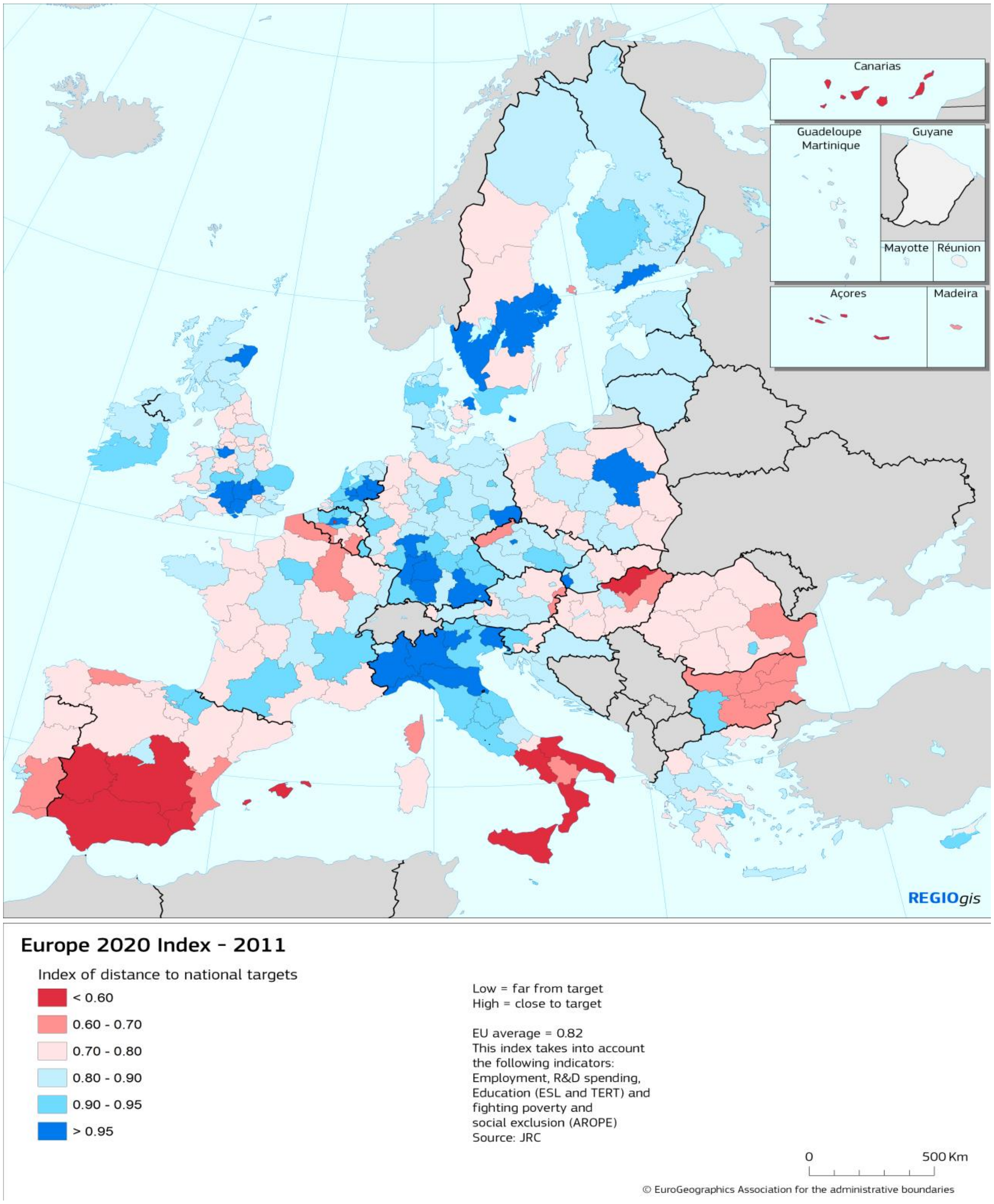
Four capital regions (Prague CZ01, Bratislava SK01, Stockholm SE11, Helsinki FI1B) are among the top-10 Europe 2020 performers. Other top performers include the Belgian region of Vlaams-Brabant (BE24), the Italian regions of Trento (ITH2) and Emilia-Romagna (ITH5), the Swedish region of Vastverige (SE23) and the German regions of Oberbayern (DE21) and Dresden (DED2). At the other extreme, Spain's performance is particularly disappointing as it is responsible for seven of the bottom-10 regions. Four of these regions are found in the southern and south-central parts of the country (Andalucia ES61, Murcia ES62, Extremadura ES43, Castilla-la-Mancha ES42) while the other three include the Canary Islands (ES70) and two small autonomous territories in Africa (Ceuta ES63 and Melilla ES64). Finally, Italy's southern regions of Sicily (ITG1) and Campania (ITF3), and the Portuguese autonomous region of the Acores islands (PT20) round out the bottom 10.

The Spanish regions of Ceuta (ES63), Melilla (ES64), Canarias (ES70), Andalucia (ES61), Extremadura (ES43), Castilla-la-Mancha (ES42), and Murcia (ES62) are among the bottom-10 performers in most of the Europe 2020 objectives regarding employment, research and development, education, and poverty and social exclusion. In addition, the Italian regions of Sicily (ITG1) and Campania (ITF3) are among the worst-10 performing regions in terms of their Europe 2020 targets on employment and poverty and social exclusion.

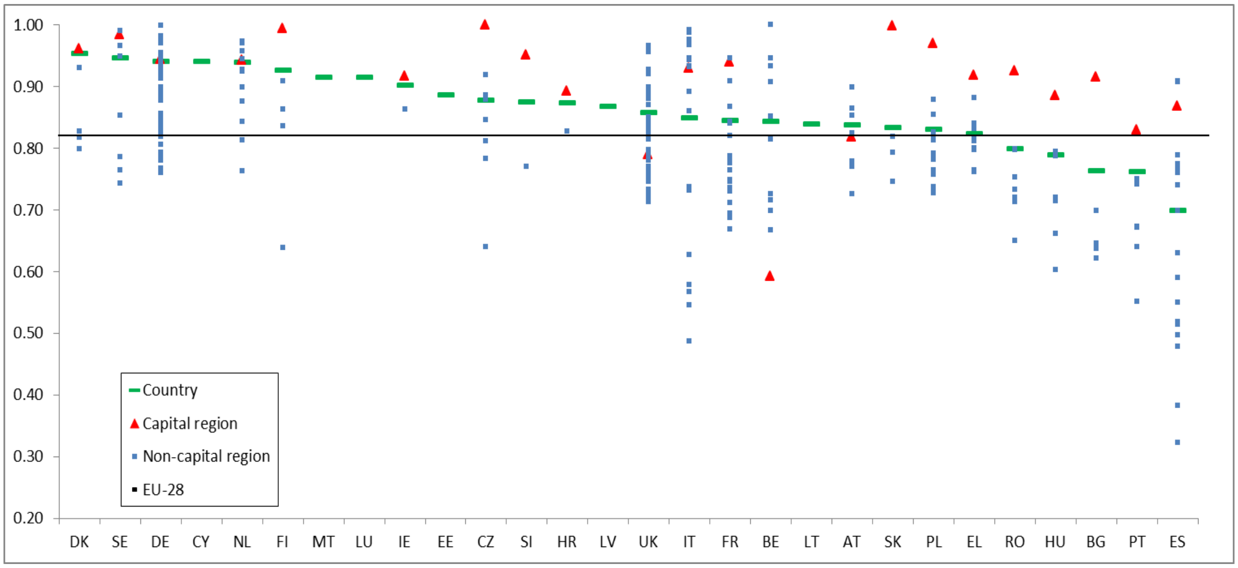
An important caveat to the above concerns the population sizes of NUTS 2 regions. In particular, some NUTS 2 regions have very large populations (e.g., Sicily ~5 million), while others very small populations (e.g., Ceuta ~82,000). Therefore, the scores of the former should be considered more reliable than those of the latter.

The following map presents the Europe 2020 Regional Index scores. While we should be mindful not to overstate the reach of this analysis, a few general patterns are worth noting. First, we see that southern and central European countries such as Spain, Bulgaria, Greece, Portugal, Romania, and Hungary fall behind Scandinavian and other northern European countries, notwithstanding the latters' more ambitious targets. Second, our analysis makes plain the significant inter-regional heterogeneity of Europe 2020 performance for many countries. The country presenting the greatest such variability is Italy, with a particularly acute North-South divide, and to a lesser, though still very substantial, degree Spain. Meanwhile, it is clear that regions in Spain, Greece, Bulgaria, Poland, and Hungary are consistently problematic in meeting their Europe 2020 objectives.

Europe 2020 Regional Index (scores range from 0.32 to 1)



Europe 2020 Regional Index Scores – reference year 2011

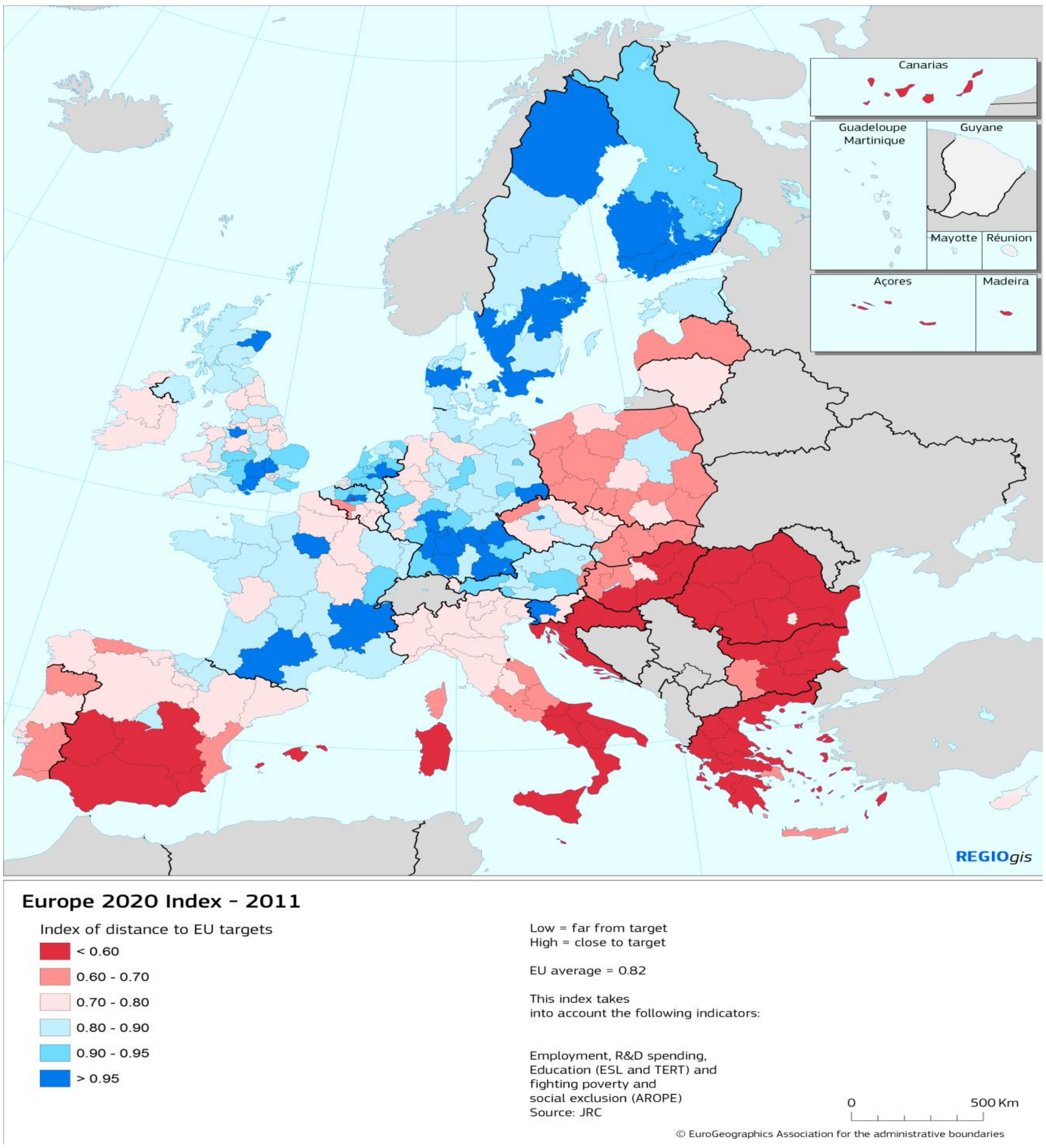


Urbanization patterns are an important factor of Europe 2020 performance. The above figure shows that capital regions almost always both (a) outperform the EU-28 aggregate score and (b) are among the top performers within countries (indeed, they often have the highest score). A remarkable exception to this trend is the region of Brussels (BE10). Brussels' very low score is primarily due to weak performance with regard to employment and poverty objectives. With a European-wide rank of 256 (out of 268), its performance stands in stark contrast to the rest of Belgium. Furthermore, it should be noted that the primary driver of this negative result is not Belgium's ambitious national targets: Brussels' rank goes up to a mere 216 if we recalculate the index with the European-wide Europe 2020 targets.

In a number of countries there is a sizable gap between the performance of the capital and next-best region (Slovakia, Romania, Poland, Portugal, Hungary, and Finland). We further observe the large regional heterogeneity in index scores for countries such as Italy, Spain, Belgium, the Czech Republic, Poland, and Slovakia, among others. This point reinforces the importance of disaggregating the index to the regional level.

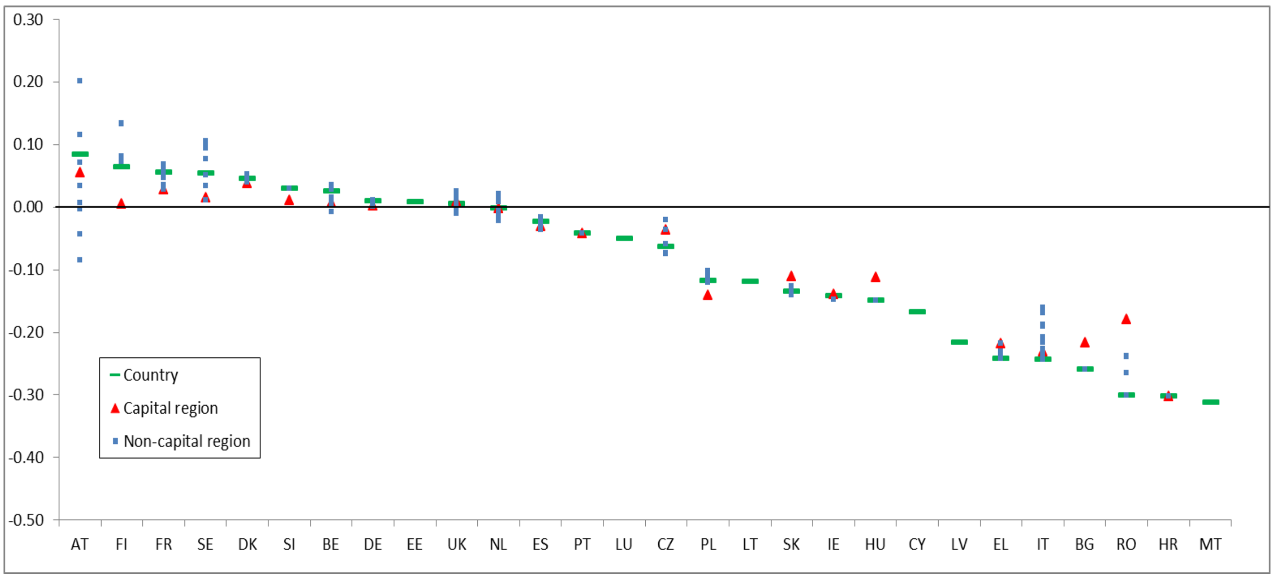
The Europe 2020 Regional Index was computed on the basis of the individual country targets. As a general rule, the targets of richer countries are more ambitious than those of poorer ones, in a way that is broadly consistent with the EU-28 wide targets. It is legitimate to ask how index scores would change should the EU-28 targets have been adopted uniformly across all European countries. The map below graphically depicts the recalculated index.

Europe 2020 Regional Index with EU-28 targets (scores range from 0.24 to 1)



The picture that emerges is not all that surprising: poorer countries with less ambitious targets do worse (often significantly so) under the EU-28 targets. The effect on relatively richer countries is muted, as they do either mildly worse or mildly better under common targets. A somewhat unexpected result of this exercise is the fact that Italy does significantly worse under common EU-28 targets. This suggests that Italy's chosen national targets may in fact be too lenient.

Europe 2020 index scores with EU-28 targets minus Europe 2020 index scores with national targets – reference year 2011



Index scores and rankings are naturally sensitive to subjective modelling choices such as the choice of weights and aggregation scheme. For this reason, we investigated the robustness of index ranks via a rigorous uncertainty and sensitivity analysis. While the ranks of a handful of regions were quite sensitive to changes in weights and aggregation (primarily due to low performance along a single Europe 2020 dimension), index ranks as a whole were quite robust.

It is our hope that European policy makers will find the Regional Europe 2020 Index useful in gauging current regional performance with respect to Europe 2020 objectives, and designing the next steps of Europe 2020's successful implementation.

Introduction

In this work we develop a composite indicator to measure regional progress in meeting the set of objectives set forth by Europe 2020, the European Commission's ten year growth strategy[2] launched in March 2010.

Europe 2020 consists of a variety of different goals involving employment, education, poverty, research and development (R&D), and environmental sustainability. These goals are quantified via European-wide numerical targets on a group of relevant economic, social, and environmental indicators. This multidimensionality calls for a conceptually sound and analytically transparent composite measure that synthesizes progress along the many different dimensions of Europe 2020.

To accommodate the heterogeneity of EU-28 countries, the above European-wide objectives were subsequently transformed into a set of more realistic national targets for individual countries. This was done for a majority of country-indicator pairs (by the member countries themselves), but not for all. Notably, the UK lacks employment, R&D, education, and poverty targets, while a handful of other countries lack targets in R&D and poverty reduction. In general, Member States selected lower national targets when the distance to the EU target was great. Only the Nordic Member States, Austria and the Netherlands set most targets higher. Nevertheless, the distance to national targets remained higher for the member states far removed from the EU targets, than for the ones close to them.

The environmental sustainability targets regarding emissions cannot be completely disaggregated to the country level, as emissions that are part of the ETS trading scheme are auctioned and traded EU-wide. Thus, any attempt at measuring progress towards meeting Europe 2020 targets must grapple with the awkward fact that desirable

[2] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

benchmarks, on the basis of which progress is assessed, may not always be available. This means that either such targets will need to be occasionally imputed, or some countries and/or indicators will need to be omitted from the analysis. In this work, we have predominantly opted for the former option by imputing national targets where they are not available, provided the corresponding EU-28 regional data are not too sparse. While we have attempted to do so with care, such imputation introduces an unavoidable degree of subjective judgment to the results that policy makers should be aware of.

To obtain a spatially refined appreciation of Europe 2020's current status and the future challenges underlying its successful implementation, our analysis is disaggregated to the regional NUTS 2 level. This poses a number of challenges regarding data availability, which for certain indicators can be quite sparse. In some cases, such considerations were pivotal in deciding whether an indicator should be included in the composite index. In particular, as there is no regional data whatsoever for the environmental sustainability indicators, we decided to drop them from the composite index. In doing so we took the view that heroic attempts at imputing regional data to these indicators (two of which also lack national targets) would be theoretically and practically indefensible, and generate more heat than light. On the other hand, poverty and social exclusion data at the NUTS 2 level are also quite sparse, with coverage around 40%. However, in this case, the existence of (a) a decent amount of NUTS 2 data; (b) well-defined national targets, and; (c) a sizable amount of NUTS 1 data, tilted the scales towards keeping this indicator in the composite measure, and proxying where necessary NUTS 2 data by available NUTS 1 or national figures.

With the above caveats in mind, we propose a straightforward methodology for the calculation of the Regional Europe 2020 Index, that can be easily applied and understood. The approach we adopt is similar to the one used in the computation of the Lisbon Index (Dijkstra, 2010). A region's progress towards meeting an individual goal is measured via the (appropriately normalized) shortfall of its actual performance with respect to its national target. Subsequently, its Europe 2020 Index score is calculated by considering a weighted arithmetic average of these percentage shortfalls over the set of all indicators.

The weighting scheme we employ assigns equal weight to the four remaining thematic areas of the Europe 2020 strategy. As this choice leads to a moderately imbalanced correlation structure between the index's components and the composite measure, we derived alternative weights that provide both high and balanced correlations. However, we chose not to adopt them, on theoretical as well as practical grounds that will be explained in Section 7.

Composite scores and rankings are inevitably sensitive to indicator weights, as well as to the choice of the aggregation framework itself. These are, by and large, subjective choices. Thus, it is useful to assess the robustness of the produced ranking by systematically considering its divergence with rankings produced under plausibly different combinations of weights and aggregation schemes. This is achieved via an uncertainty and sensitivity analysis along the lines discussed in Saisana et al. (2005). We observed that weights and aggregation were roughly equally important input factors. Moreover, while the ranks of a handful of regions were quite sensitive to changes in weights and aggregation (primarily due to low performance along a single Europe 2020 dimension), index ranks as a whole were quite robust.

This paper is structured as follows. Section 2 provides brief remarks on the Europe 2020 strategy and its specific objectives and targets, while Section 3 reviews relevant prior work. Section 4 introduces the theoretical framework of the Europe 2020 Index and Section 5 discusses data availability for its various components. Section 6 takes up the issue of data and target imputation. Section 7 applies the theoretical framework of Section 4 to the Europe 2020 context. It provides a brief discussion of the index's results and statistical properties. To gauge the index's robustness, Section 8 presents an uncertainty and sensitivity analysis of index rankings. Section 9 provides concluding remarks. In the Appendix the index is recalculated under the assumption of common EU-28 wide targets and the results are briefly compared to those obtained in Section 7. Finally, the Appendix concludes with maps depicting regional performance in the Europe 2020 thematic areas.

The Europe 2020 Strategy

Europe 2020 is a ten-year economic strategy introduced by the European Commission in March 2010. Its stated aim is to promote "smart, sustainable, and inclusive" growth. Europe 2020 identifies eight headline targets to be attained by the end of 2020, involving (a) employment; (b) research and development; (c) climate/energy; (d) education; and (e) social inclusion and poverty reduction.

Table 1 summarizes these broad objective areas for the entire EU, along with the specific targets they entail. Each target is abbreviated by the acronym appearing in parentheses.

Table 1: Europe 2020 objectives and targets for the EU as a whole

1. Employment a) 75% of the 20-64 year-olds to be employed (EMP)
2. R&D b) 3% of the EU's GDP to be invested in R&D (R&D)
3. Climate change and energy sustainability a) greenhouse gas emissions 20% (or even 30%, if the conditions are right) lower than 1990 (GHG) b) 20% of energy from renewables (REN) c) 20% increase in energy efficiency compared to 2005 (EFF)
4. Education a) Reducing the rates of early school leaving below 10% (ESL) b) at least 40% of 30-34–year-olds completing third level education (TERT)
5. Fighting poverty and social exclusion a) at least 20 million fewer people in or at risk of poverty and social exclusion (AROPE)

As mentioned in the introduction, for some of the Europe 2020 objectives, national targets have also been determined in addition to the EU-28 ones. These national targets translate European-wide goals to levels that are realistically attainable for individual countries. Such adjustments are necessary, given the intrinsic heterogeneity of the EU.

Table 2 lists these national Europe 2020 targets. The figures for EMP, R&D, ESL, and TERT were directly obtained from Eurostat. Eurostat does not list national targets for GHG since national commitments on these indicators involve just emissions not covered by the EU Emissions Trading System (EU ETS), which are not distinguished in Eurostat statistics. The situation is less clear for EFF where some national targets are listed on a pdf file[3] that can be downloaded the Commission's Europe 2020 website, but no national targets of any sort are listed in Eurostat or other Commission webpages or sources. We suppose this is because the EFF target has largely been considered symbolic, as it is not easily measurable. REN targets are available but we choose not to list them, in light of the fact that this indicator will be omitted from the composite index due to complete lack of regional data.

AROPE national targets involve numerical goals regarding the reduction of the total number of people at risk of poverty or social exclusion. However, given that the effort to reduce the number of people at risk should be seen in light of the total population of country and its share of population at risk, we transformed the national AROPE Europe 2020 targets into population percentages using 2009 national data on total population ($POP2009$), number of people AROPE ($\#AROPE$), and the Europe 2020 target reduction ($EU2020AROPE\_Target$). The first two types of data we obtained from Eurostat, while the third by visiting each country's individual webpage at the Europe 2020 Commission website.[4] For the sake of analytic precision, the AROPE target of country c expressed as a population percentage, denoted by $AROPE\_Target_c$, is equal to:

$$AROPE\_Target_c = \frac{\#AROPE2009_c - EU2020AROPE\_Target_c}{Pop2009_c}.$$

[3]Found at the URL: http://ec.europa.eu/europe2020/pdf/targets_en.pdf

[4] http://ec.europa.eu/europe2020/europe-2020-in-your-country/index_en.htm

Looking at Table 2, we see that none of the listed national targets are available for the United Kingdom (UK). A handful of other countries have either not reported targets for certain objectives (Croatia for AROPE), or have provided targets that are of a different nature than the Europe 2020 figures (the Czech Republic for R&D and Sweden for AROPE).

We imputed targets for these missing values and highlight them in Table 2 in red. We defer the explanation of how this imputation was performed to Section 6.

Table 2: Europe 2020 national and EU-28 targets

Country	EMP	R&D	ESL	TERT	AROPE
EU-28	75	3	10	40	19.5
AT	77	3.76	9.5	38	14.0
BE	73.2	3	9.5	47	16.4
BG	76	1.5	11	36	43.5
CY	75	0.5	10	46	20.2
CZ	75	2.35	5.2	32	13.6
DE	75	3	9.9	42	19.4
DK	80	3	9.9	40	17.1
EE	76	3	9.5	40	19.7
EL	70	0.67	9.7	32	22.8
ES	74	3	15	44	21.3
FI	78	4	8	42	13.8
FR	75	3	9.5	50	14.9
HR	59	1.4	4	35	27.9
HU	75	1.8	10	30.3	24.7
IE	67	2	15	26	21.3
IT	67	1.53	15	26	21.4
LT	72	1.9	8.9	40	24.3
LU	73	2.3	9.9	40	16.6
LV	73	1.5	13.4	34	31.8
MT	62.9	0.67	29	33	18.4
NL	80	2.5	7.9	40	14.5
PL	71	1.7	4.5	45	23.5
PT	75	2.7	10	40	23.2
RO	70	2	11.3	26.7	41.7
SE	80	4	9.9	40	14.2
SI	75	3	5.0	40	14.7
SK	72	1	6.0	40	16.6
UK	77.1	2.87	12.3	42.9	18.6

Source: http://ec.europa.eu/europe2020/europe-2020-in-your-country/index_en.htm
Imputed targets in red.

Related work

In this section we briefly discuss two composite indicators, the Regional Lisbon and Competitiveness Indices, which are relevant to the Europe 2020 index.

DG REGIO Regional Lisbon Index

Perhaps the most relevant prior work can be found in the development of the Regional Lisbon Index by DG REGIO (Dijkstra, 2010). The Regional Lisbon Index was designed to measure regional performance in meeting the goals set forth by the 2000 Lisbon Treaty. Though the Lisbon and Europe 2020 growth strategies are largely distinct, there are some similarities between their thematic areas (e.g., employment, education, and research and development). NUTS 2 regions were classified into three broad categories: (i) Convergence; (ii) Transition; and (iii) Regional Competitiveness and Employment (RCE).

Regional performance in a particular indicator was measured via the ratio of its distance to the target over the maximum such distance across all regions. The Lisbon Index was calculated as the simple average of performance across indicators and particular attention was paid to intuitiveness and consistency. The index's developers sought to ensure that identical levels of performance received identical scores across time. Moreover, double-counting was avoided by considering just indicators that were mutually exclusive. An additional concern involved ensuring that identical percentage increases across indicators resulted in the same increase for the value of the index.

DG REGIO Regional Competitiveness Index

This development of the Regional Competitiveness Index (RCI) (Dijkstra et al. 2011; Annoni and Dijkstra, 2013) was substantially more complex than that of the Lisbon Index. In contrast to the specificity of the Lisbon targets, competitiveness is a broad concept that is open to subjective interpretation. Therefore, the developers of the RCI had to first devise a coherent theoretical framework with which to measure competitiveness. To this end, eleven pillars of competitiveness were defined and then grouped into three broad categories (i.e., "Basic," "Efficiency," and "Innovation"). Each pillar involved a number of indicators, ranging from three to fourteen, and pillar scores were obtained by taking the simple average of the associated indicator scores, suitably normalized.

European NUTS 2 regions were divided in five groups, reflecting their stage of economic development. This stratification was performed on the basis of regional per capita GDP as compared to the EU average. The RCI was obtained by a weighted linear aggregation of pillar scores. The weights assigned to each pillar varied from group to group, to accommodate heterogeneity in country priorities. The Innovation pillar weights went up as the level of development rose, while the converse was true for the Basic pillar (Efficiency pillar weights were fixed across groups).

Theoretical Framework of the Europe 2020 Regional Index

In this section, we describe the methodology we used to calculate the index. Specifically, we provide a brief description of its mathematical structure and discuss issues related to outlier treatment.

Before going into the specifics of the Europe 2020 context, we provide an abstract description of our framework. Consider a region r and a set of I indicators. For each indicator i, define the constant f_i to equal 1 if higher values correspond to better performance, and -1 if they correspond to worse performance. The variables z_{ri} and x_{ri} denote region r's target and performance with respect to indicator i. The set of targets for a region r is denoted by the I-dimensional vector $z_r = (z_{r1}, z_{r2}, \dots, z_{rI})$, while its actual performance by the vector $(x_{r1}, x_{r2}, \dots, x_{rI})$.

Focusing on indicator i, the variable d_{ri} denotes the distance between a region r's performance relative to its target (with no extra "points" awarded if the target is met):

$$d_{ri} = \max(f_i * (z_{ri} - x_{ri}), 0) .$$

Focusing on a particular indicator i, region r's performance relative to its target z_{ri} is captured by the variable y_{ri}, defined as:

$$y_{ri} = 1 - \frac{d_{ri}}{max_{r \in R} \; d_{ri}}.$$

The above quantity ranges between a minimum of 0, if region r has the greatest distance-to-target with respect to indicator i, and a maximum of 1, if it meets or exceeds the target. Clearly, higher values imply better performance.

<u>Note:</u> In the version of the Index we present in this report, the normalization of distances to target (i.e., the denominator in the expression of y_{ri}) was done by considering the maximum such distance over both (i) years 2010 and 2011, and (ii) the version of the Index with national and EU-28 targets. This ensures comparability over time and national/EU-28 targets.

Suppose now that each indicator i is assigned a weight of $w_i \geq 0$, such that $\sum_{i=1}^{I} w_i = 1$. Taking a weighted arithmetic average over the set of all indicators yields region r's total performance $y_r(w)$:

$$y_r(w) = \sum_{i=1}^{I} w_i * y_{ri}.$$

This quantity is bounded below by 0 and above by 1, and higher values imply better performance. The above framework for measuring progress towards meeting a set of targets was used in the computation of the Regional Lisbon Index (Dijkstra, 2010). It is reminiscent of (though distinct from) scholarly contributions in the measurement of different multidimensional phenomena involving thresholds and cut-off points, such as poverty (Alkire and Foster, 2011). Section 7 applies this framework to the Europe 2020 context.

Data

When constructing the Europe 2020 index, we adopted the following general scheme:

	Year
Europe 2020 Index	X
EMP	X
R&D	X
ESL	Average of (X-1)-X-(X+1)
TERT	Average of (X-1)-X-(X+1)
AROPE	X+1

Construction of Europe 2020 index for a year X

For instance, to calculate the Europe 2020 Index for year 2011, we considered employment and R&D data from 2011, 2010-2012 averages for education (ESL and TERT) data, and 2012 poverty and social exclusion data. The consideration of a three year moving average for ESL and TERT was pursued in light of many regions' small sample sizes for these indicators. The one-year look-ahead convention for AROPE was adopted to accommodate the temporal structure of the EU-SILC survey from which these data are drawn.

Given the above scheme, let us focus on the 2011 version of the Europe 2020 index and consider each indicator's data availability.

- *Employment (EMP)*. This indicator has 100% coverage over the entire EU-28 NUTS 2 regions.
- *R&D spending (R&D)*. Data for the Niederbayern (DE22), Oberpfalz (DE23), and Luxembourg (LU00) were unavailable.
- *Education (ESL and TERT).* ESL data for Burgenland (AT11), Aland (FI20), Corse (FR83), Bratislavskykraj (SK01) were unavailable. TERT data for Aland (FI20), Corse (FR83), Valle d'Aosta (ITC2), and Regiao Autonomao dos Acores (PT20), were unavailable.
- *Fighting poverty and social exclusion (AROPE).* Compared to EMP, R&D, ESL and TERT, coverage for AROPE is very low (around 40%), since many countries do not report regional poverty statistics. Indeed, Germany, France, Portugal, and

the United Kingdom report only national data, while Belgium, Greece, the Netherlands, and Hungary report just national and NUTS 1 data.

Data and Target Imputation

Data. We decided to use available NUTS 1 or, where that was not possible, national data, to extrapolate NUTS 2 missing data. Meanwhile, if a region lacked data in more than 2 indicators, then it was discarded altogether from the analysis. This means that the index was not calculated for the French Departements d'Outre Mer regions (FR91,FR92,FR93,FR94).

As mentioned above, the overwhelming majority of missing data was due to the AROPE indicator. Here, NUTS 1 data were used to extrapolate AROPE data for NUTS 2 regions in Belgium, Greece, the Netherlands, and Hungary, while national figures were used in the case of France, Germany, Portugal, and the United Kingdom. 2010 figures are used for Belgium, Greece, and Ireland, as the respective 2011 data were not yet available. Moreover, Luxembourg's R&D indicator was proxied from existing 2010 data. We did not impute values for other missing data involving R&D, ESL, and TERT (10 data points in total), because we did not feel confident in the validity of our estimates.

Targets. When national targets for a particular country-indicator pair were not available, a reasonable estimate, based on the national targets of countries with roughly similar "starting points", was derived. Let us illustrate our approach with an example based on the UK's TERT target. In 2009 the UK had a TERT of 41.5, which was similar to that of DK (40.7), NL (40.5), LT (40.6), PT (71.2), FR (43.2), and CY (43.9). TERT targets for the latter countries were available, so we went ahead and computed the distances of their 2009 rates to their corresponding targets[5], which was equal to 1.4. This represents an average distance to target for countries with similar TERT starting points to the UK. To

[5] Where this distance was negative (as in the case of DK and NL), meaning that a country had already attained its target in 2009, we truncated it to 0.

impute the UK target, we added to its 2009 value this average distance to target, resulting in a target of 41.5+1.4=42.9.

Following the above procedure, we imputed all missing targets. The resulting figures are shown in Table 3.

Table 3: Imputed National Targets (in red)

Country	EMP	R&D	ESL	TERT	AROPE
CZ	-	2.35	-	-	-
HR	-	-	-	-	27.9
SE	-	-	-	-	14.2
UK	77.1	2.87	12.3	42.9	18.6

The imputed data and targets were then used in the computation of the Europe 2020 Index.

The Europe 2020 Regional Index

In constructing the Europe 2020 Regional Index, we utilized the theoretical framework laid out in Section 4. The set of indicators consisted of EMP, R&D, ESL, TERT, and AROPE. To reflect balance across objectives, the component scores of indicators EMP, R&D and AROPE were assigned weight 0.25, while a weight of 0.25 was assigned to the average of ESL and TERT. This was done to reflect equal *a priori* importance for the objectives of promoting employment, research and innovation, education, and poverty reduction.

Recalling the notation of Section 4, and letting $y_{rEDU} = \frac{1}{2}y_{rESL} + \frac{1}{2}y_{rTERT}$, a region r's Europe 2020 score, denoted by $y_{rEU2020}$, was given by the following expression:

$$y_{rEU2020} = 0.25 * \left(y_{rEMP} + y_{rR\&D} + \frac{1}{2}y_{rESL} + \frac{1}{2}y_{rTERT} + y_{rAROPE}\right)$$
$$= 0.25 * (y_{rEMP} + y_{rR\&D} + y_{rEDU} + y_{rAROPE}).$$

If a region was missing data for a given objective (i.e., EMP, R&D, EDU [both ESL and TERT], and AROPE) of the Europe 2020 index, then the weight of this component was uniformly assigned to all others. If, on the other hand, missing data involved only one of ESL and TERT comprising the EDU objective, then the weight of the missing indicator was assigned to the other one within the EDU objective.

Correlation Structure

Before presenting the Europe 2020 regional index results and rankings, we comment on the correlation structure of the composite indicator. We found all four of its components ($\boldsymbol{y_{EMP}}, \boldsymbol{y_{R\&D}}, \boldsymbol{y_{EDU}}, \boldsymbol{y_{AROPE}}$) to be positively correlated with each other as well as to the composite scores $\boldsymbol{y_{EU2020}}$, at very high significance (maximum p-value < .001).

Table 4: Correlation matrix of composite components and index (N=268)

	y_{EMP}	$y_{R\&D}$	y_{EDU}	y_{AROPE}	y_{EU2020}
y_{EMP}	1	0.24	0.37	0.70	0.77
$y_{R\&D}$		1	0.45	0.12	0.72
y_{EDU}			1	0.22	0.68
y_{AROPE}				1	0.66

The component y_{AROPE} presents the widest set of correlations, with values ranging from 0.12 for $y_{R\&D}$ to 0.70 for y_{EMP}. This could be due to the high amount of imputed data (roughly 60% of total). Meanwhile, component-composite correlations range from a maximum of 0.77 (y_{EMP}) to a minimum of 0.66 ($y_{R\&D}$). Thus, we see that the Europe 2020 index reflects similar importance for the four thematic areas of employment, research and development, education, and poverty.

Europe 2020 Regional Index Results and Discussion

Table 5 lists the regions with the top and bottom-10 Europe 2020 index scores. Moreover, it lists the bottom 10 performers in the index's five components. The top-10 regions for each component are not well-defined, as many regions attain perfect scores of 1 in the various dimensions of the Index. Thus, we simply the note the number of such regions attaining perfect scores, implying that they meet or exceed their respective national targets (this figure is not provided for AROPE because of the very high amount of data imputed from national and NUTS 1 figures).

Table 5: Top and Bottom-10 regions in Europe 2020 Regional Index and its components (listed in descending and ascending order, respectively).

	Top-10	Bottom-10
y_{EU2020}	BE24*, CZ01*, DE21, SK01, FI1B, ITH2, SE23, ITH5, SE11, DED2	ES63, ES64, ES70, ITG1, ES61, ES43, ES62, ITF3, ES42, PT20
y_{EMP}	59 regions meet or exceed target	ES63, ITF3, ES61, HU31, ITG1, ITF6, ES64, HU32, ES70, ES43
$y_{R\&D}$	38 regions meet or exceed target	FI20, SE32, SE21, AT11, SE31, ES63, ES64, ES53, FR83, UKK3
y_{ESL}	87 regions meet or exceed target	PT20, ES63, PT30, ES53, ES61, ES62, ES43, ES64, PT15, ES42
y_{TERT}	52 regions meet or exceed target	SK02, ES64, DEE0, DE93, PT18, CZ04, DEA5, SK04, DE94, DEA4
y_{AROPE}	N/A	ITG1, ITF3, ITF4, ITF5, ITF6, BE10, ES63, ES64, ES70, AT13

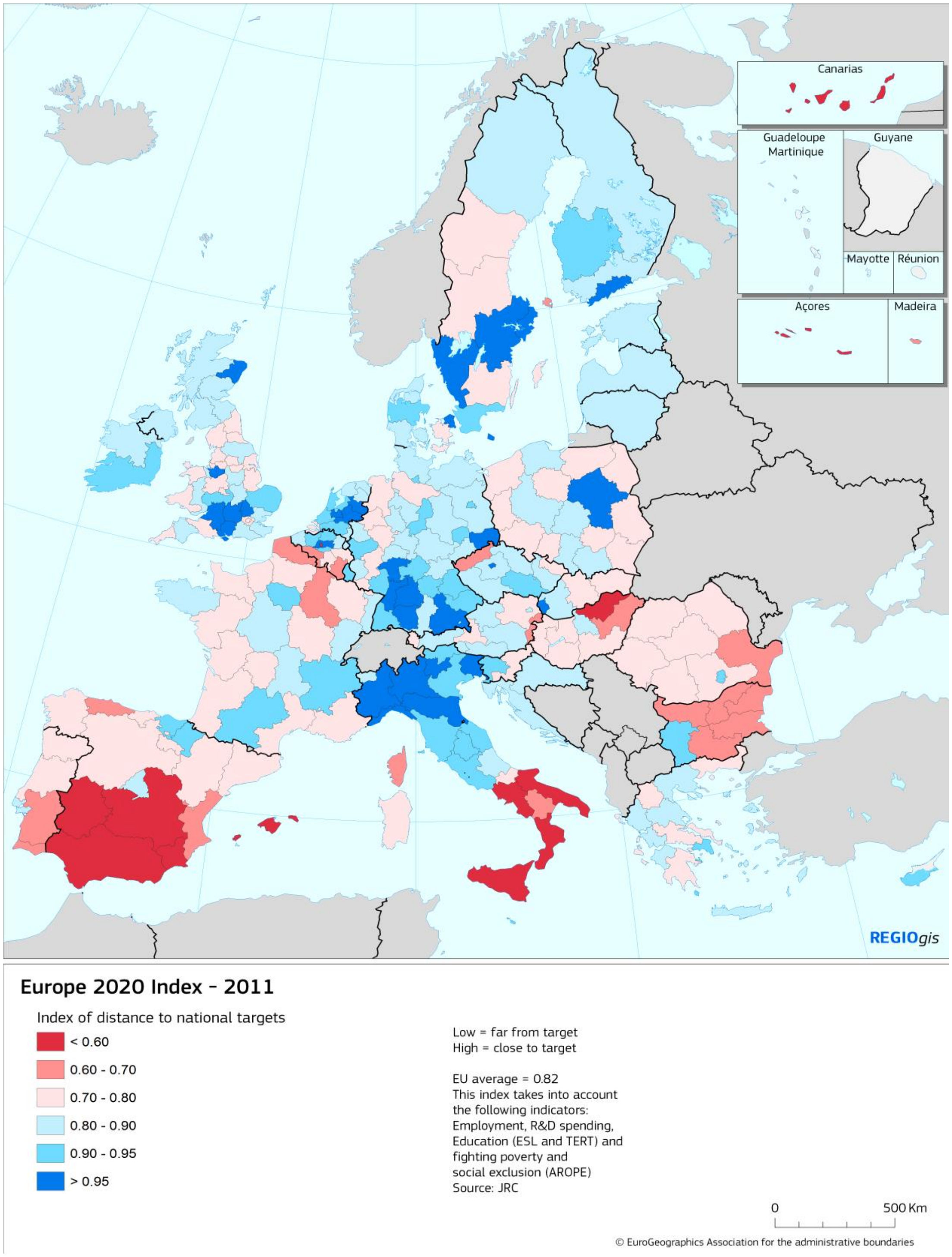
Note: Top-10 regions not listed for AROPE due to very high amount of imputed data. An asterisk denotes regions exceeding or meeting all targets.

Four capital regions (Prague CZ01, Bratislava SK01, Stockholm SE11, Helsinki FI1B) are among the top-10 Europe 2020 performers. Other top performers include the Italian regions of Trento (ITH2) and Emilia-Romagna (ITH5), the Belgian region of Vlaams-Brabant (BE24), the Swedish region of Vastverige (SE23) and the German regions of

Oberbayern (DE21) and Dresden (DED2). At the other extreme, Spain's performance is particularly disappointing as it is responsible for seven of the bottom-10 regions. Four of these regions are found in the southern and south-central parts of the country (Andalucia ES61, Murcia ES62, Extremadura ES43, Castilla-la-Mancha ES42) while the other three include the Canary Islands (ES70) and two small autonomous territories in Africa (Ceuta ES63 and Melilla ES64). Finally, Italy's southern regions of Sicily (ITG1) and Campania (ITF3), and the Portuguese autonomous region of the Acores islands (PT20) round out the bottom 10.

Map 1 below presents the results of the Europe 2020 Regional Index. It reinforces the point that countries present notable heterogeneity in their Europe 2020 performance, and confirms the necessity of looking into the regional dimension of Europe 2020. The country presenting the greatest such variability is Italy, with a particularly acute North-South divide. Meanwhile, it is clear that regions in Spain, Greece, Bulgaria, and Hungary are consistently problematic in meeting their Europe 2020 objectives.

Map 1: Europe 2020 Regional Index Scores



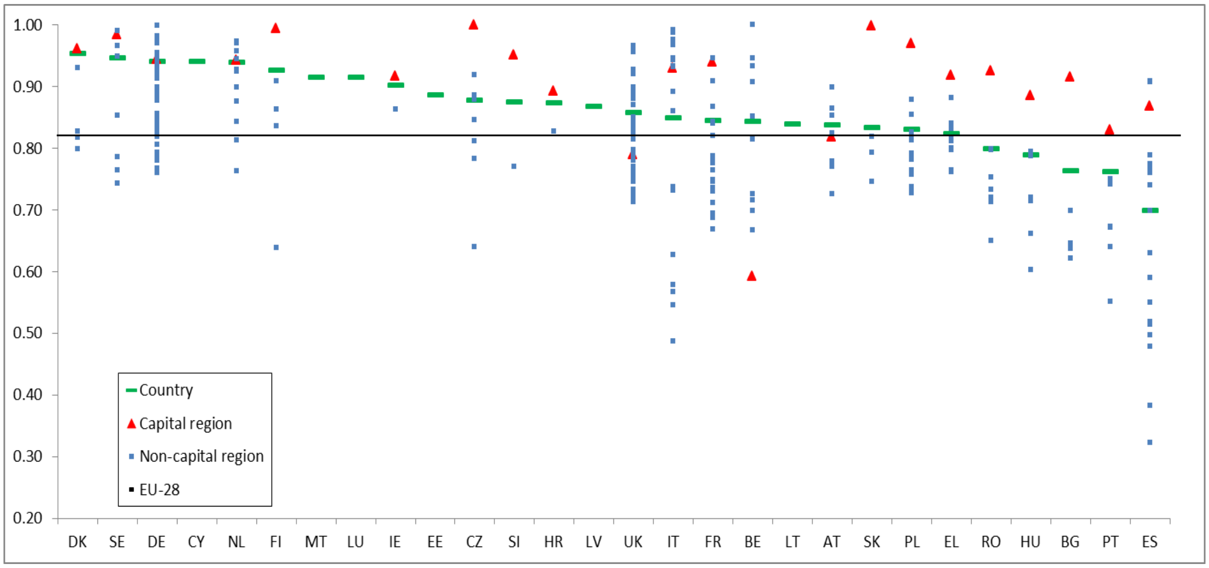


Figure 1: Europe 2020 Regional Index scores for each country and capital/non-capital regions – reference year 2011

Figure 1 shows that capital regions almost always (a) surpass the EU-28 aggregate score and (b) are among the top performers within countries (indeed, they often have the highest score). A remarkable exception to this trend is the region of Brussels (BE10). Brussels' very low score is primarily due to weak performance with regard to employment and poverty objectives. With a European-wide rank of 255 (out of 268), its performance stands in stark contrast to the rest of Belgium. Furthermore, it should be noted that the primary driver of this negative result is not Belgium's ambitious national targets: Brussels' rank goes up to a mere 223 if we uniformly impose the European-wide Europe 2020 targets (see Appendix).

In a number of countries there is a sizable gap between the performance of the capital and next-best region (Slovakia, Romania, Poland, Portugal, Hungary, and Finland). Figure 1 further captures the large regional heterogeneity in index scores for countries such as Italy, Spain, Belgium, the Czech Republic, and Slovakia, among others. This point reinforces the importance of disaggregating the index to the regional level.

Uncertainty and Sensitivity Analysis

Every region score on the Europe 2020 index depends on subjective modelling choices: objective-category structure, selected variables, imputation or not of missing data, normalization, weights, aggregation method, among other elements. The robustness analysis we perform is aimed at assessing the joint impact of such modelling choices on the rankings, and thus to complement the Europe 2020 ranks with error estimates stemming from the unavoidable uncertainty in the choices made.

Our assessment of the Europe 2020 index was based on a combination of Monte Carlo experiments and multi-modelling approach, following good practices suggested in the composite indicators literature (Saisana *et al.*, 2005; Saisana *et al*., 2011). We focused on two key issues: (i) the choice of objective weights and (ii) aggregation function. Undoubtedly, we could have incorporated other uncertain elements of the index to our robustness analysis (e.g.., normalization scheme). However, results from this type of analysis in other contexts suggest that the choice of weights and aggregation are the two assumptions with the highest impact on index rankings.

Weight uncertainty

In our analysis, we allow index component weights to be unequal across Europe 2020 thematic areas in a controlled fashion. In particular, weights for EMP, R&D, EDU, and AROPE are sampled uniformly from the set $W = \{w \in \mathfrak{R}^4\colon\ w_i \in [0.2, 0.3], \forall\, i \in \{1,2,3,4\},\ \sum_{i=1}^{4} w_i = 1\}$. That is, each indicator's weight is allowed to deviate at most 20% from its nominal value of 0.25, and all the weights must sum to 1.

Aggregation function uncertainty

Regarding the choice of aggregation formula, the simple arithmetic average has been criticized on the basis of its perfectly substitutable structure, whereby high performance in one indicator can fully compensate for low performance in another. We relaxed this strong perfect substitutability assumption by introducing a parametric family of aggregating functions that are known as generalized weighted means (Decancq and Lugo, 2013). Parameterized by $\beta \in \Re$, the generalized weighted mean of a vector x given weights w is given by:

$$y^{\beta}(x, w) = \left(\sum_{i} w_i x_i^{\beta}\right)^{\frac{1}{\beta}}.$$

When $\beta = 1$ (0), the above function reduces to a weighted arithmetic (geometric) mean. The parameter β can be interpreted in terms of the elasticity of substitution between the different dimensions of the index, e, where $e = \frac{1}{1-\beta}$. The smaller the value of β, the lower the substitutability between the different dimensions of performance (note that the case $\beta = 1$ corresponding to an arithmetic mean implies infinite substitutability).

For values of $\beta < 1$, generalized weighted means reflect a preference for balanced performance across the different dimensions of the index. Such balance is desirable in our context, so for the purposes of our uncertainty analysis we mainly considered this range of β. Specifically, in our simulations we considered five values for β, namely $\beta \in$ {0, 0.25, 0.50, .75, 1}, ranging from the arithmetic to the geometric mean.

Generating weight-aggregation samples

We generated a sample of 1500 weight-aggregation pairs in the following manner. First, we drew a vector of weights w from the set $W = \{w \in \Re^4\colon\ w_i \in [0.2, 0.3], \forall\, i \in \{1,2,3,4\},\ \sum_{i=1}^{4} w_i = 1\}$. Using these weights w, regional Europe 2020 scores were computed via their generalized weighted means for $\beta \in \{0, 0.25, 0.50, 0.75, 1\}$, where the aggregations were performed at the thematic area level.[6]

[6] As the minimum component score was 0.08, no renormalization was needed.

Table 6. Sources of uncertainty in Europe 2020 index

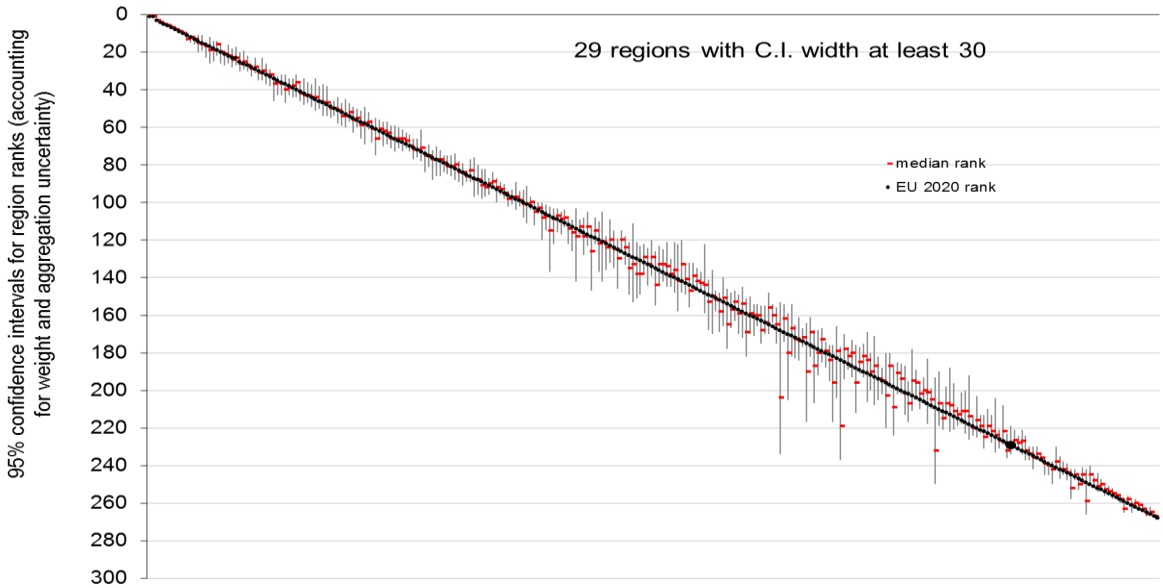
	Reference	***Alternative***
I. Uncertainty in the aggregation formula	Weighted arithmetic average, i.e., $\beta = 1$	Generalized weighted mean $\beta \in \{0,0.25,0.50,0.75,1\}$
II. Uncertainty in the weights	Equal weights $w_i = 0.25, \forall i$	Uniform distribution over set $W = \{w\colon\ w_i \in [0.2,0.3], \forall\ i \in \{1,2,3,4\},\ \sum_{i=1}^{4} w_i = 1\}$.

Uncertainty Analysis Results

Figure 2 below presents the results of our uncertainty analysis. Regions are ordered from best to worst according to their reference rank (black dot), the red dot being the median rank. All published Europe 2020 ranks lay within the simulated 95% confidence intervals. However, it is also true that regional ranks vary significantly with changes in weights and aggregation function. Indeed, 20 regions have 95% confidence interval widths between 30 and 39 (indicated in red in Table 3). Confidence intervals widths for 4 regions lie between 40 and 49 (AT13, UKI62, DE94, DEB1), for 3 regions between 50 and 59 (AT32, SE31, SE32), and one region (SE21) has an interval width of 81.

These big swings are driven by uneven performance in the different dimensions of the index. The case of the Swedish region of Smaland med oarna (SE21) is highly illustrative. SE21 does extremely well in all dimensions of the index except R&D, for which Sweden's ambitious R&D target, in combination to SE21 GDP's relatively low share of R&D lead to a normalized distance from target of 0.23. This is in stark contrast to performance in EMP, EDU, and AROPE, which all exceed 0.95. Aggregation functions with $\beta < 1$ will accentuate this imbalance and lead to much worse performance than under arithmetic aggregation.

Figure 2: Uncertainty analysis results for EU2020 region ranks (based on 1500 weight-aggregation pairs)



For full transparency and information, Table 7 reports the Europe 2020 ranks together with the simulated median values and 95% confidence intervals in order to better appreciate the robustness of the results to the choice of weights and aggregation function. Confidence intervals wider than 30 are highlighted in red.

Table 7. Uncertainty analysis results for Europe 2020 region ranks.

	EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI
BE24	1	1	[1,1]	DE26	68	66	[61,73]	DE27	135	144	[126,155]	UKG2	202	207	[195,217]
CZ01	1	1	[1,1]	FR71	69	67	[63,71]	PL22	136	133	[123,144]	FR81	203	195	[178,211]
DE21	3	3	[3,3]	FI19	70	70	[64,73]	AT21	137	133	[125,142]	FR25	204	196	[189,205]
SK01	4	4	[4,4]	ES22	71	72	[66,77]	SK02	138	134	[121,145]	UKE4	205	202	[195,210]
FI1B	5	5	[5,5]	ES21	72	72	[66,76]	DK03	139	138	[130,145]	FR41	206	200	[193,207]
ITH2	6	6	[6,6]	BE31	73	71	[61,78]	EL42	140	136	[121,148]	SK04	207	201	[183,218]
SE23	7	7	[7,7]	NL11	74	75	[72,84]	EL41	141	142	[122,158]	FR63	208	205	[199,210]
ITH5	8	8	[8,8]	DE72	75	75	[69,81]	EL14	142	133	[120,148]	SE32	209	232	[193,250]
SE11	9	9	[9,10]	UKJ2	76	77	[72,88]	UKN0	143	141	[133,149]	PT11	210	207	[190,219]
DED2	10	10	[9,10]	AT22	77	77	[70,86]	BE22	144	147	[132,156]	ES11	211	215	[206,221]
ITH4	11	13	[11,14]	UKJ4	78	77	[72,86]	PL41	145	139	[132,145]	PL43	212	207	[198,214]
ITC1	12	12	[11,15]	HR04	79	79	[75,84]	NL13	146	142	[135,147]	ITG2	213	208	[188,222]
DE11	13	13	[12,16]	DEG0	80	81	[75,85]	CZ07	147	143	[137,148]	PL62	214	211	[196,221]
NL31	14	15	[11,20]	ITC2	81	81	[75,86]	EL23	148	144	[122,159]	FR26	215	213	[209,219]
ITC3	15	16	[11,19]	DE50	82	80	[74,88]	DEE0	149	153	[141,168]	UKG3	216	211	[201,218]
DE12	16	17	[15,23]	DE92	83	84	[78,89]	EL25	150	150	[136,170]	RO21	217	211	[200,223]
PL12	17	19	[12,26]	UKH3	84	84	[79,91]	RO11	151	152	[147,158]	ITF2	218	214	[192,226]
NL22	18	19	[14,25]	CZ02	85	86	[83,89]	DK02	152	158	[148,169]	FR53	219	220	[213,224]
DE71	19	16	[14,22]	EE00	86	83	[77,89]	EL22	153	151	[140,166]	PL42	220	216	[203,225]
DE14	20	20	[16,26]	HU10	87	88	[76,97]	UKK2	154	165	[146,178]	UKC1	221	219	[213,223]
ITC4	21	21	[19,27]	DE24	88	88	[80,96]	RO42	155	157	[148,167]	AT34	222	225	[213,231]
SE12	22	22	[16,26]	EL43	89	91	[82,98]	HU22	156	153	[147,163]	BE35	223	219	[210,225]
UKJ3	23	24	[18,28]	UKE2	90	92	[82,97]	UKI1	157	159	[149,170]	RO31	224	222	[213,228]
UKM5	23	23	[17,27]	CZ03	91	90	[87,96]	SK03	158	154	[145,172]	HU33	225	224	[204,233]
UKH2	25	26	[20,30]	PL21	92	89	[84,92]	DEA3	159	169	[151,182]	UKE1	226	227	[221,231]
UKJ1	26	25	[19,29]	DED4	93	92	[87,100]	PL34	160	159	[150,170]	BE33	227	222	[208,229]
DK01	27	27	[22,30]	NL42	94	93	[89,96]	PL51	161	160	[154,171]	UKK3	228	232	[223,236]
UKK1	28	29	[27,33]	UKF1	95	95	[90,98]	ES51	162	160	[154,166]	HU23	229	229	[219,234]
NL21	29	28	[23,31]	ES30	96	98	[94,102]	DEC0	163	168	[155,175]	RO12	230	226.5	[221,231]
UKD6	30	31	[29,35]	LV00	97	97	[93,101]	UKD4	164	164	[155,170]	UKL1	231	228	[224,231]
DE23	31	30	[23,35]	FR43	98	97	[89,104]	PL31	165	156	[148,170]	FR22	232	227	[221,234]
DE25	32	32	[26,37]	AT33	99	99	[94,102]	FR61	166	160	[154,164]	BG33	233	232	[224,237]
SI02	33	32	[29,38]	FI1D	100	101	[93,108]	HU21	167	165	[156,175]	ES12	234	234	[230,237]
SE22	34	37	[32,46]	IE01	101	101	[91,111]	SE21	168	204	[153,234]	BE34	235	236	[230,242]
FR62	35	36	[33,43]	ITF1	102	100	[97,104]	CZ08	169	162	[154,174]	FR21	236	234	[230,236]
DE13	36	37	[32,43]	DE73	103	105	[99,112]	UKI2	170	180	[159,205]	FR30	237	236	[233,237]
BE23	37	40	[32,47]	PL11	104	103	[100,106]	PL32	171	167	[154,182]	PT18	238	239	[236,245]
ITI1	38	39	[34,43]	SE33	105	108	[100,120]	UKD3	172	173	[165,183]	PT15	239	240	[238,245]
NL41	39	38	[34,44]	AT31	106	107	[101,115]	DEA5	173	174	[161,184]	FR83	240	242	[238,250]
DE30	40	36	[32,44]	BE25	107	115	[102,137]	FR51	174	172	[167,177]	BE32	241	238	[230,241]
NL32	41	42	[37,46]	UKM2	108	109	[103,122]	AT32	175	190	[164,217]	HU32	242	242	[235,247]
ITI2	42	43	[34,48]	DE80	109	107	[103,116]	FR82	176	169	[161,182]	RO22	243	242	[238,245]
ITH3	43	43	[36,47]	CZ05	110	109	[105,117]	AT12	177	187	[168,207]	BG42	244	244	[239,248]
FR10	44	44	[37,49]	FR52	111	108	[104,113]	ES13	178	180	[168,192]	AT11	245	252	[242,258]
DEB3	45	44	[34,51]	NL12	112	114	[109,122]	SI01	179	173	[167,185]	CZ04	246	245	[242,248]
DEA2	46	46	[38,50]	UKL2	113	116	[109,126]	UKC2	180	179	[174,188]	PT30	247	250	[244,253]
DE91	47	47	[37,54]	EL12	114	118	[103,142]	ES24	181	184	[176,195]	BG32	248	245	[241,250]
CY00	48	47	[38,54]	FR42	115	113	[109,117]	DE94	182	196	[176,217]	FI20	249	259	[242,266]
ITH1	49	50	[47,55]	DE40	116	118	[108,128]	EL24	183	179	[166,204]	BG34	250	245	[240,250]
BE21	50	50	[46,54]	LT00	117	113	[105,123]	SE31	184	219	[177,237]	ES52	251	248	[246,252]
ITI3	51	51	[44,58]	UKK4	118	126	[112,147]	PL33	185	178	[170,194]	ITF5	252	251	[244,254]
DED5	52	54	[47,59]	FI1C	119	115	[108,122]	FR23	186	182	[177,189]	BG31	253	250	[247,253]
ITI4	53	54	[45,60]	DEA4	120	122	[110,137]	UKD7	187	180	[173,193]	HU31	254	253	[251,256]
DK04	54	52	[47,57]	EL21	121	121	[105,142]	DE93	188	196	[176,212]	BE10	255	254	[251,256]
UKH1	55	56	[49,63]	UKF2	122	124	[118,136]	NL34	189	185	[177,191]	ES53	256	255	[252,258]
NL23	56	55	[50,60]	PT17	123	120	[109,132]	PL52	190	182	[175,193]	ITF6	257	256	[254,258]
RO32	57	59	[51,66]	DEA1	124	125	[115,135]	EL11	191	184	[169,206]	ITF4	258	258	[255,260]
DE22	58	58	[49,69]	DK05	125	130	[119,146]	UKD1	192	190	[180,200]	PT20	259	263	[257,265]
NL33	59	57	[52,61]	HR03	126	120	[115,126]	EL13	193	187	[171,208]	ES42	260	258	[256,261]
UKG1	60	61	[56,68]	PL63	127	124	[118,133]	ES41	194	194	[182,205]	ITF3	261	261	[259,265]
EL30	61	66	[55,75]	UKM6	128	135	[121,149]	ES23	195	195	[188,202]	ES62	262	260	[258,263]
CZ06	62	61	[56,66]	AT13	129	133	[111,153]	DEB1	196	203	[180,220]	ES43	263	261	[260,263]
DE60	63	62	[57,70]	DEB2	130	138	[121,151]	PL61	197	187	[180,199]	ES61	264	263	[261,265]
IE02	64	63	[57,69]	DEF0	131	138	[123,149]	UKF3	198	209	[187,224]	ITG1	265	266	[264,267]
BG41	65	66	[59,71]	FR24	132	129	[122,138]	UKE3	199	191	[185,202]	ES70	266	265	[262,266]
MT00	66	66	[59,73]	UKM3	133	133	[124,144]	RO41	200	194	[186,202]	ES64	267	267	[266,267]
LU00	67	66	[60,71]	FR72	134	129	[120,139]	PT16	201	202	[187,213]	ES63	268	268	[268,268]

The relative importance of weights and aggregation to the variation in Europe 2020 ranks

In this section we will investigate the relative importance of uncertainty in weights and aggregation in the Europe 2020 index. As the following analysis will make clear, variation in country ranks is overwhelmingly driven by the choice of aggregation function.

Following Saisana et al. (2005), our measure of robustness is the absolute shift in rank with respect to the benchmark choice of equal weights and linear aggregation, which we denote by the variable ΔR. That is, given a region r and a weight-aggregation pair (w, β), we are interested in the following quantity (here, $Rank_r(w, \beta)$ denotes region r's rank under the version of our composite index that uses weights w and aggregation β):

$$\Delta R_r(w, \beta) = \left| Rank_r(w^{ref}, 1) - Rank_r(w, \beta) \right|.$$

Given a weight-aggregation pair (w, β), a compelling aggregate measure of robustness can be found in the *average* shift in rank (over the set of regions) that (w, β) results in, denoted by $\mu_{\Delta R}(w, \beta)$, (here C is the number of regions):

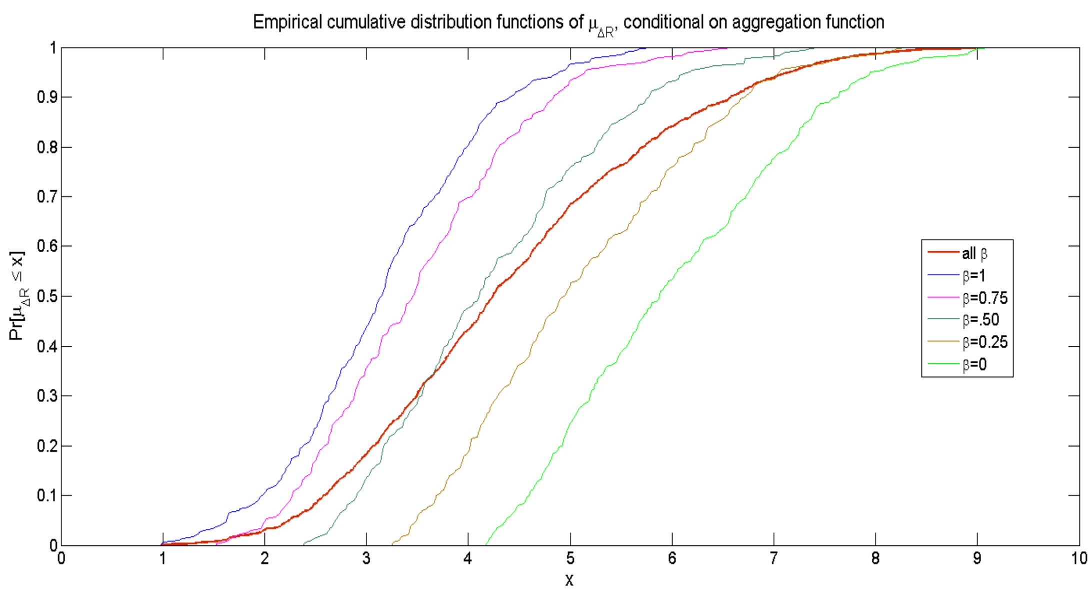
$$\mu_{\Delta R}(w, \beta) = \frac{1}{C} * \sum_{c=1}^{C} \Delta R_c(w, \beta)$$

Focusing on our simulated sample, the sample mean and standard deviation for $\mu_{\Delta R}$ are given by: $\overline{\mu_{\Delta R}} = 4.4$, $\sigma_{\mu_{\Delta R}} = 1.5$. Zooming in now on the choice of aggregation, we denote by $\overline{\mu_{\Delta R}}(\beta)$ and $\sigma_{\mu_{\Delta R}}(\beta)$ the expectation and sample standard deviation of $\mu_{\Delta R}$ conditional on different values of β. We have:

β	$\overline{\mu_{\Delta R}}(\beta)$	$\sigma_{\mu_{\Delta R}}(\beta)$
1	3.2	0.96
0.75	3.5	1.00
0.50	4.25	1.11
0.25	5.1	1.16
0	6.0	1.16

Figure 3 below depicts the empirical cumulative distribution function (cdf) of $\mu_{\Delta R}$, as well as the analogous distributions conditional on the 5 values of β.

Figure 3: Empirical cumulative distribution function of mean shift in rank.



Note: This figure can be read in the following way. Suppose we are interested in the pth percentiles of the conditional and unconditional distributions of $\mu_{\Delta R}$, where the conditioning is performed on the choice of aggregation function. Then, draw a straight horizontal line originating at point p on the y-axis. This line will intersect the 5 conditional (blue) and 1 unconditional (red) cdfs at different points, and the x-coordinates of these points will be the pth percentiles of the respective distributions. For instance, conditional on $\beta = 0.25$, 75 percent of the simulated Europe 2020 rankings have an average absolute shift in rank of at most 6, with respect to the original Europe 2020 ranking.

Figure 3 makes graphically clear how the choice of aggregation does not seem to have a big effect on the observed variance of $\mu_{\Delta R}$. Indeed, if we fix a value for β, we see that the resulting cdfs of $\mu_{\Delta R}$ have a similar shape, with their means being translated.

This point can be made also algebraically. Define the *sensitivity index* S_w (S_β) to be the fractional contribution to the sample variance of $\mu_{\Delta R}$ due to the uncertainty in the weights (aggregation scheme) of the Europe 2020 index. Equivalently, let $S_{w\beta}$ denote this contribution due to the interaction effect of uncertainty in both weights and aggregation.[7] Simple calculations yield: $S_w = 0.48$, $S_\beta = 0.43$, $S_{w\beta} = 0.09$.

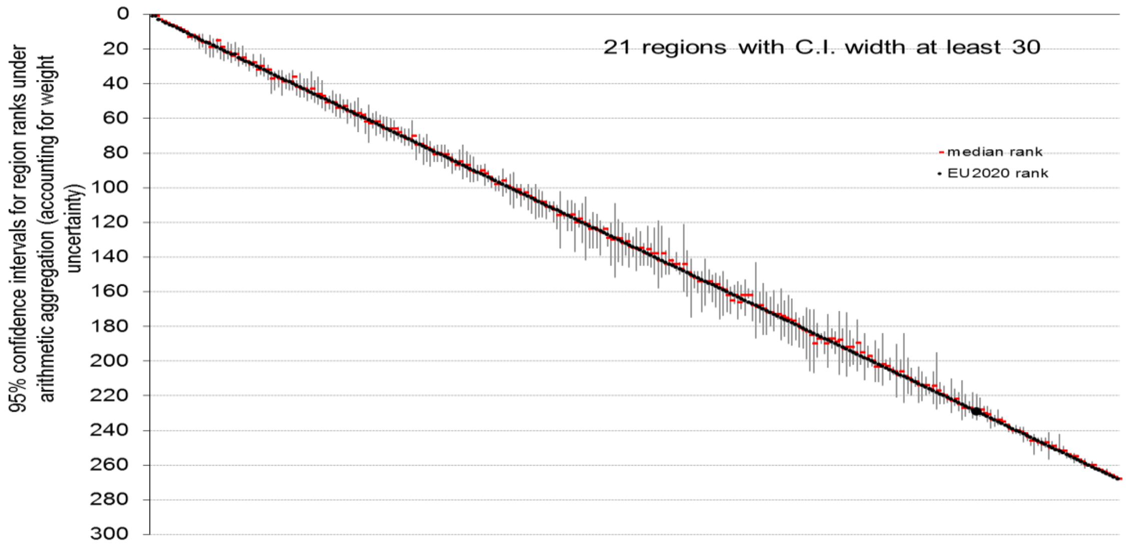
Thus, we see that the choice of weights is responsible for 48% of the sample variance of $\mu_{\Delta R}$, while the choice of aggregation function for 43%. Thus, we see that these contributions are quite high and balanced.

Uncertainty analysis under fixed arithmetic aggregation

Given the above results, we may be interested in asking how robust are the Europe 2020 ranks under exclusively arithmetic aggregation. Figure 4 shows the simulated country ranks given a fixed choice of arithmetic aggregation. Indeed, comparing it to Figure 2, we see that confidence intervals are narrower, with 21 countries having a width of 30 or above. Out of those, 18 regions are in the 30-39 range (EL21, EL41, EL14, EL23, EL25, UKI2, AT32, DE94, EL24, SE31, DE93, EL11, EL13, DEB1, FR81, SK04, ITF2) and 3 in the 40-49 (SE21, SE32, AT13).

[7] For details on the precise definition of sensitivity indices see Saisana et al. (2005).

Figure 4: Uncertainty analysis results under fixed arithmetic aggregation.



As before, the primary factor behind the wide confidence intervals for these countries is uneven performance across the Europe 2020 thematic areas. This issue is particularly applicable to Greek regions.

For completeness, Table 8 below presents the uncertainty analysis results for each region for the entire sample, as well as the restricted sample corresponding to fixed arithmetic means. Once again, confidence intervals greater than 30 are highlighted in red. The higher robustness of the $\boldsymbol{\beta} = \mathbf{1}$ case is apparent. However, it is also worth noting that the confidence intervals of 43 regions become wider under fixed arithmetic aggregation, by an average margin of 1.4. This is an alternative way of establishing that weight uncertainty does play a role in the observed variance of the Europe 2020 ranks, even when keeping the choice of arithmetic aggregation fixed.

Table 8: Uncertainty analysis results with fixed arithmetic aggregation.

	EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI		EU2020 Rank	Median	95%CI
BE24	1	1	[1,1]	DE26	68	66	[61,73]	DE27	135	135.5	[123,148]	UKG2	202	203.5	[193,212]
CZ01	1	1	[1,1]	FR71	69	68	[65,72]	PL22	136	135	[125,145]	FR81	203	202	[184,214]
DE21	3	3	[3,3]	FI19	70	70	[65,74]	AT21	137	138	[132,145]	FR25	204	203	[199,205]
SK01	4	4	[4,4]	ES22	71	72	[66,76]	SK02	138	135.5	[122,145]	UKE4	205	205	[198,211]
FI1B	5	5	[5,5]	ES21	72	72	[66,76]	DK03	139	138	[132,146]	FR41	206	206	[203,208]
ITH2	6	6	[6,6]	BE31	73	70	[61,78]	EL42	140	138	[123,150]	SK04	207	208	[190,221]
SE23	7	7	[7,7]	NL11	74	75.5	[72,84]	EL41	141	142	[119,158]	FR63	208	206	[199,210]
ITH5	8	8	[8,9]	DE72	75	75	[69,80]	EL14	142	138	[122,152]	SE32	209	209	[184,224]
SE11	9	9	[8,10]	UKJ2	76	76	[71,87]	UKN0	143	144	[136,150]	PT11	210	210	[198,219]
DED2	10	10	[9,10]	AT22	77	77	[69,85]	BE22	144	142	[129,150]	ES11	211	212	[204,220]
ITH4	11	13	[11,14]	UKJ4	78	78	[73,88]	PL41	145	144	[141,146]	PL43	212	212	[209,215]
ITC1	12	12	[11,15]	HR04	79	81	[76,85]	NL13	146	144	[137,148]	ITG2	213	214	[203,224]
DE11	13	13	[12,16]	DEG0	80	80	[75,85]	CZ07	147	147	[143,150]	PL62	214	214	[206,223]
NL31	14	15	[11,20]	ITC2	81	81	[75,85]	EL23	148	144	[121,160]	FR26	215	214	[209,220]
ITC3	15	16	[11,19]	DE50	82	81	[75,89]	DEE0	149	149	[136,163]	UKG3	216	216	[213,219]
DE12	16	16	[15,23]	DE92	83	83	[78,88]	EL25	150	151	[141,175]	RO21	217	214.5	[206,225]
PL12	17	19	[12,25]	UKH3	84	85	[80,92]	RO11	151	152	[148,158]	ITF2	218	217	[195,228]
NL22	18	19	[14,25]	CZ02	85	87	[83,90]	DK02	152	154	[148,161]	FR53	219	219	[212,225]
DE71	19	15	[14,22]	EE00	86	85	[78,90]	EL22	153	154	[148,172]	PL42	220	220	[214,225]
DE14	20	19	[16,26]	HU10	87	87	[75,95]	UKK2	154	154	[141,168]	UKC1	221	222	[219,224]
ITC4	21	22	[19,27]	DE24	88	87	[79,94]	RO42	155	154	[147,161]	AT34	222	223	[210,230]
SE12	22	22	[16,26]	EL43	89	90	[81,97]	HU22	156	156	[150,166]	BE35	223	222	[216,226]
UKJ3	23	24	[17,28]	UKE2	90	91	[82,97]	UKI1	157	156	[149,169]	RO31	224	225	[218,229]
UKM5	23	23	[16,27]	CZ03	91	91	[87,96]	SK03	158	158	[151,176]	HU33	225	227	[211,234]
UKH2	25	26	[19,30]	PL21	92	90	[87,93]	DEA3	159	159	[148,174]	UKE1	226	227	[219,232]
UKJ1	26	25	[18,29]	DED4	93	92	[86,99]	PL34	160	162	[153,172]	BE33	227	227	[223,230]
DK01	27	27	[22,30]	NL42	94	94	[90,97]	PL51	161	165	[157,173]	UKK3	228	228	[218,233]
UKK1	28	29	[27,33]	UKF1	95	96	[94,100]	ES51	162	162	[156,167]	HU23	229	230	[219,234]
NL21	29	28	[23,31]	ES30	96	98	[94,102]	DEC0	163	166	[154,176]	RO12	230	228	[221,232]
UKD6	30	32	[29,36]	LV00	97	98	[93,102]	UKD4	164	162	[156,170]	UKL1	231	230	[226,232]
DE23	31	30	[23,35]	FR43	98	96	[89,105]	PL31	165	162	[153,174]	FR22	232	231	[226,235]
DE25	32	32	[25,36]	AT33	99	99	[94,103]	FR61	166	162	[158,164]	BG33	233	234	[228,239]
SI02	33	32	[29,38]	FI1D	100	100	[92,110]	HU21	167	168	[159,177]	ES12	234	234	[231,238]
SE22	34	37	[32,46]	IE01	101	101	[91,112]	SE21	168	169	[143,187]	BE34	235	234	[228,237]
FR62	35	36	[33,44]	ITF1	102	101	[98,106]	CZ08	169	168	[160,178]	FR21	236	235	[232,237]
DE13	36	37	[32,42]	DE73	103	104	[98,111]	UKI2	170	170	[155,185]	FR30	237	237	[236,238]
BE23	37	39	[32,47]	PL11	104	103	[100,107]	PL32	171	172	[160,185]	PT18	238	239	[236,241]
ITI1	38	39	[35,43]	SE33	105	105	[98,113]	UKD3	172	172	[163,180]	PT15	239	240	[239,242]
NL41	39	39	[34,44]	AT31	106	106	[100,115]	DEA5	173	173	[159,183]	FR83	240	240	[237,242]
DE30	40	36	[32,44]	BE25	107	108	[98,118]	FR51	174	173	[167,176]	BE32	241	241	[238,243]
NL32	41	42	[38,47]	UKM2	108	108	[101,117]	AT32	175	174	[158,188]	HU32	242	242	[238,247]
ITI2	42	43	[34,48]	DE80	109	108.5	[102,117]	FR82	176	175	[165,186]	RO22	243	244	[243,246]
ITH3	43	43	[37,48]	CZ05	110	111	[107,118]	AT12	177	176	[162,190]	BG42	244	246	[243,249]
FR10	44	45	[37,50]	FR52	111	111	[108,114]	ES13	178	177	[164,191]	AT11	245	246	[242,254]
DEB3	45	43	[33,49]	NL12	112	113	[108,120]	SI01	179	179	[172,188]	CZ04	246	247	[244,249]
DEA2	46	46	[38,51]	UKL2	113	116	[110,124]	UKC2	180	181	[175,192]	PT30	247	248	[244,252]
DE91	47	46	[36,52]	EL12	114	115	[102,135]	ES24	181	182	[174,193]	BG32	248	247	[244,250]
CY00	48	47	[38,54]	FR42	115	116	[114,118]	DE94	182	183	[169,199]	FI20	249	250	[241,257]
ITH1	49	51	[47,56]	DE40	116	116	[107,125]	EL24	183	185	[170,206]	BG34	250	249	[246,251]
BE21	50	51	[47,55]	LT00	117	115.5	[107,125]	SE31	184	190	[170,207]	ES52	251	251	[248,252]
ITI3	51	51	[44,57]	UKK4	118	120	[109,137]	PL33	185	187	[178,198]	ITF5	252	252	[242,254]
DED5	52	54	[46,59]	FI1C	119	118	[113,123]	FR23	186	187	[184,190]	BG31	253	252	[249,253]
ITI4	53	54	[46,60]	DEA4	120	120	[109,132]	UKD7	187	190	[183,196]	HU31	254	254	[251,256]
DK04	54	53	[49,57]	EL21	121	121	[105,142]	DE93	188	187	[173,204]	BE10	255	255	[253,257]
UKH1	55	56	[49,63]	UKF2	122	124	[118,135]	NL34	189	187	[181,193]	ES53	256	255	[253,259]
NL23	56	56	[51,60]	PT17	123	123	[114,135]	PL52	190	189	[183,196]	ITF6	257	257	[255,258]
RO32	57	58	[50,65]	DEA1	124	124.5	[115,135]	EL11	191	188	[171,208]	ITF4	258	258	[256,260]
DE22	58	57	[48,68]	DK05	125	126	[119,139]	UKD1	192	193	[181,201]	PT20	259	260	[256,262]
NL33	59	58	[54,61]	HR03	126	124	[122,127]	EL13	193	192	[172,209]	ES42	260	260	[259,261]
UKG1	60	62	[57,69]	PL63	127	129	[123,134]	ES41	194	192	[182,203]	ITF3	261	260	[258,262]
EL30	61	63	[52,74]	UKM6	128	130	[120,145]	ES23	195	195	[187,202]	ES62	262	262	[261,263]
CZ06	62	62	[57,66]	AT13	129	129	[109,152]	DEB1	196	189.5	[176,206]	ES43	263	263	[262,264]
DE60	63	62	[56,70]	DEB2	130	129.5	[118,143]	PL61	197	195	[189,202]	ES61	264	264	[264,265]
IE02	64	64	[58,69]	DEF0	131	132	[120,145]	UKF3	198	198.5	[184,211]	ITG1	265	265	[262,266]
BG41	65	66	[59,71]	FR24	132	131	[126,139]	UKE3	199	197	[191,204]	ES70	266	266	[265,266]
MT00	66	66	[59,73]	UKM3	133	134	[126,146]	RO41	200	200	[197,203]	ES64	267	267	[267,267]
LU00	67	66	[60,71]	FR72	134	135	[128,140]	PT16	201	203.5	[188,212]	ES63	268	268	[268,268]

Conclusions

In this report, we have developed a composite index to measure regional progress in meeting objectives set forth by the Europe 2020 strategy. Due to data unavailability, the environmental sustainability goals have been omitted from the analysis, while, in many cases, poverty and social exclusion data had to be imputed. Performance along the thematic areas of the Europe 2020 strategy was computed via an appropriately normalized shortfall measure. The final composite scores were calculated by assigning equal weight to each dimension of the index and taking their arithmetic average.

While we should be mindful not to overstate the reach of this analysis, a few general patterns are worth noting. First, we see that southern and central European countries such as Spain, Bulgaria, Greece, Portugal, Poland, Hungary and Romania fall behind Scandinavian and other northern European countries, despite the latters' more ambitious targets. Second, our analysis makes plain the significant inter-regional heterogeneity of Europe 2020 performance for many countries. The cases of Spain and Italy are particularly suggestive in this regard.

Index scores and rankings are naturally sensitive to subjective modelling choices such as the choice of weights and aggregation scheme. For this reason, we investigated the robustness of index ranks via a rigorous uncertainty and sensitivity analysis. While the ranks of a handful of regions were sensitive to changes in weights and aggregation (largely due to highly unbalanced performance across the index's dimensions), index ranks as a whole were quite robust.

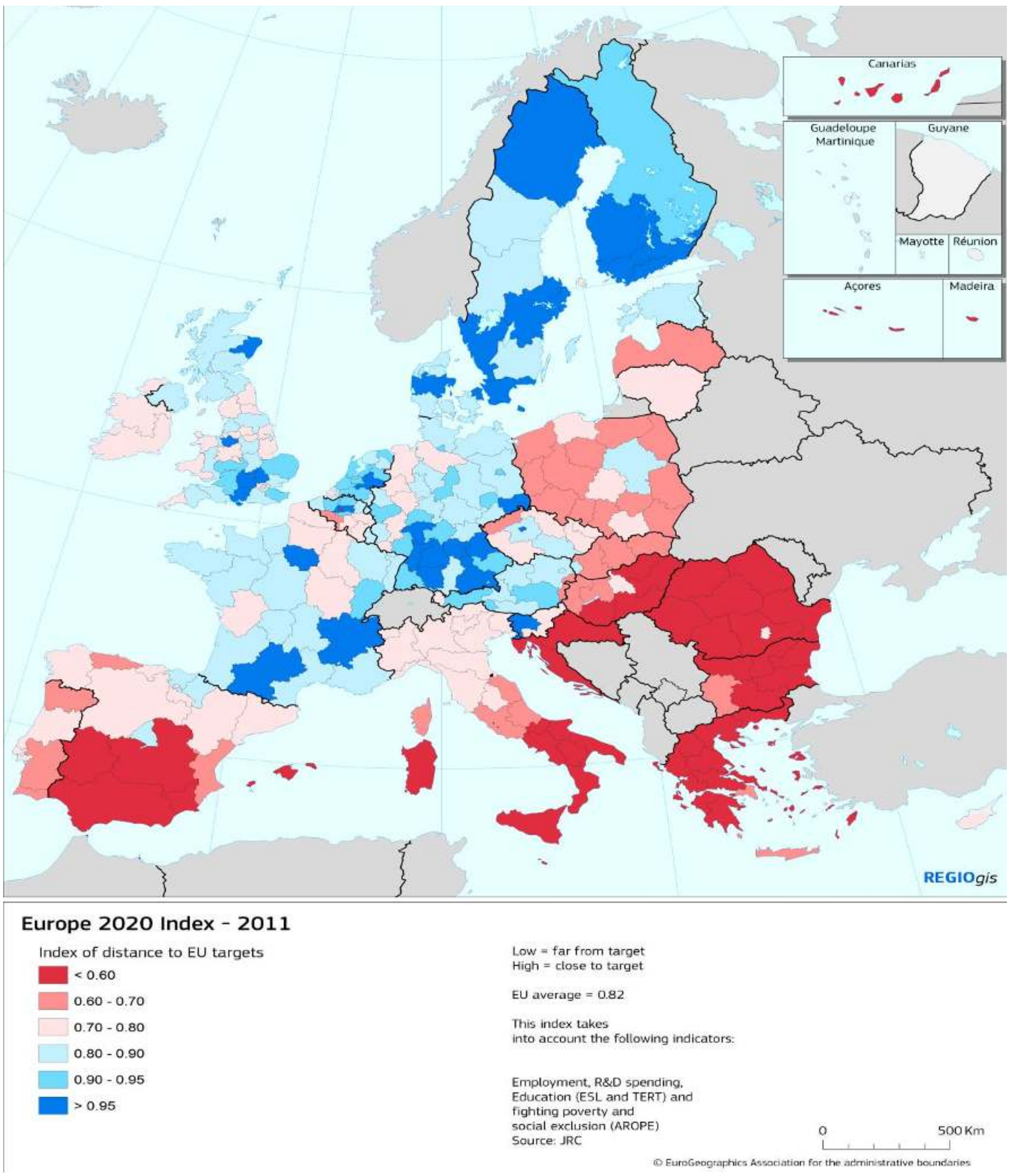
It is our hope that European policy makers will find the Regional Europe 2020 Index useful in gauging current regional performance with respect to Europe 2020 objectives, and designing the next steps of Europe 2020's successful implementation.

Appendix

A1: The Europe 2020 Regional Index with Common Targets

The Europe 2020 Regional Index was computed on the basis of the individual country targets shown in Tables 2 and 3. As discussed in Section 2, these differentiated targets are meant to address the heterogeneity of EU-28 countries.

Map 2: Europe 2020 regional scores under common EU-28 targets



The imposition of common targets lowers the average of regional scores (it is now 0.71 compared to 0.78 under differentiated targets) and increases their standard deviation (0.20 compared to 0.14). Figure 5 below shows the recalculated index scores, broken down by country.

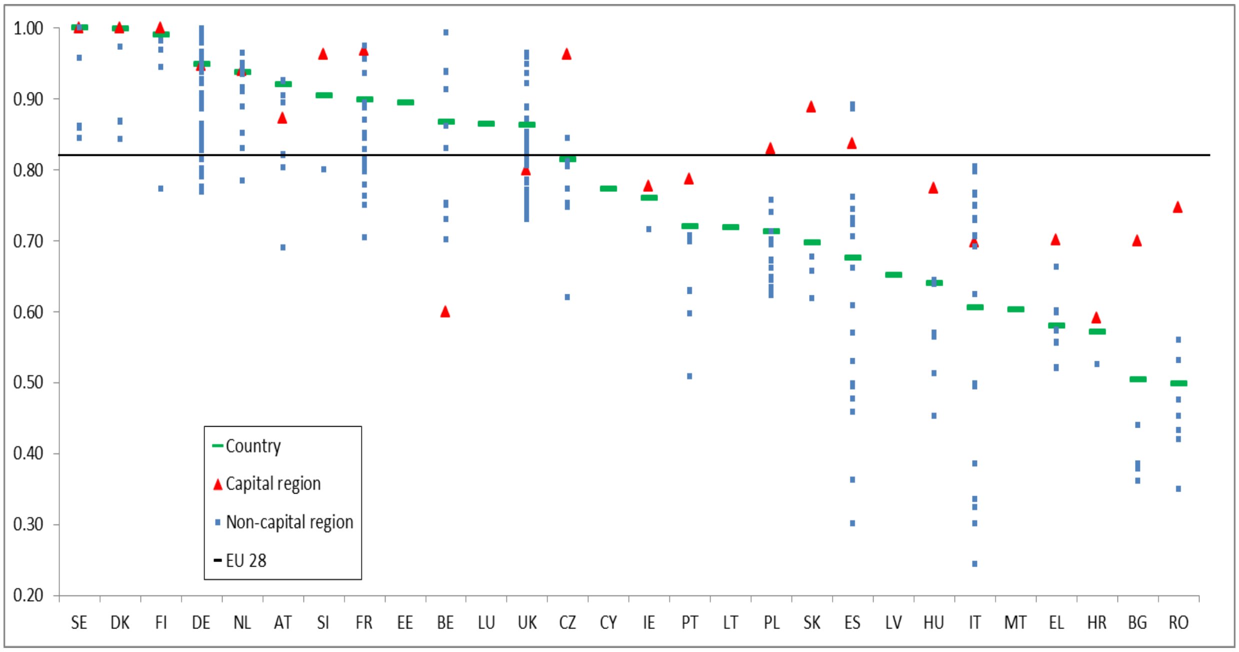


Figure 2: Europe 2020 Regional Index scores with EU-28 targets for each country and capital/non-capital regions – reference year 2011

To compare the two versions of the index, let $y^C_{rEU2020}$ denote a region r's score under the assumption of common targets, and define

$$\Delta y_{rEU2020} = y^C_{rEU2020} - y_{rEU2020},$$

as the difference between its original Europe 2020 score and its version with common EU-28 targets.

Figure 6 provides a graphical representation of the differences $\Delta y_{rEU2020}$. The picture that emerges is not all that surprising: poorer countries with less ambitious targets do worse (often significantly so) under the EU-28 targets. The effect on relatively richer countries is muted, as they do either mildly worse or mildly better under common targets.

A somewhat unexpected result of this exercise is the fact that Italy does significantly worse under common EU-28 targets. This suggests that Italy's chosen national targets may in fact be too lenient.

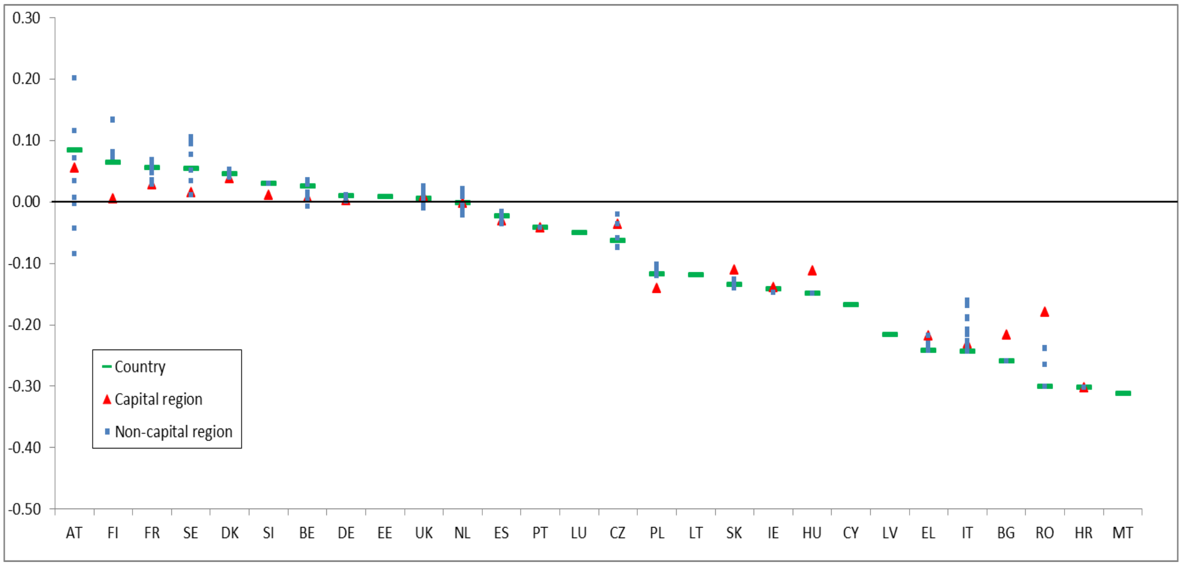
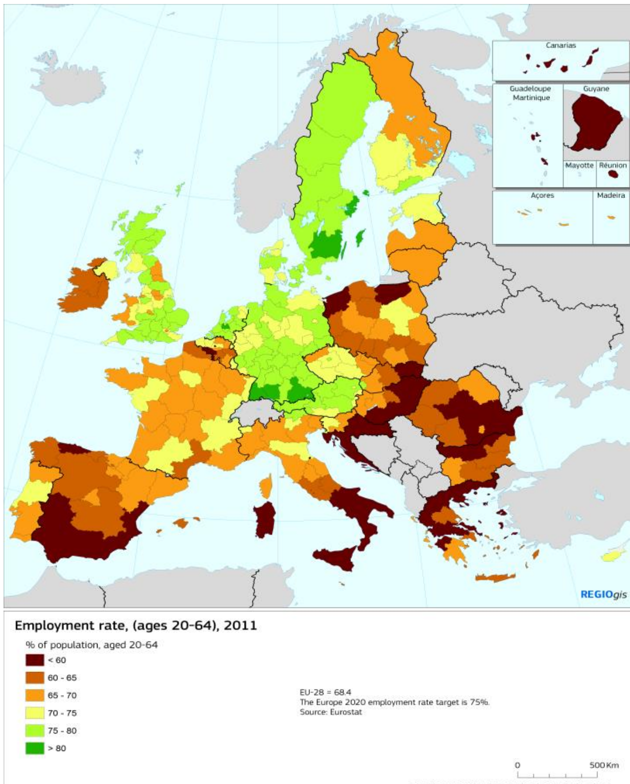
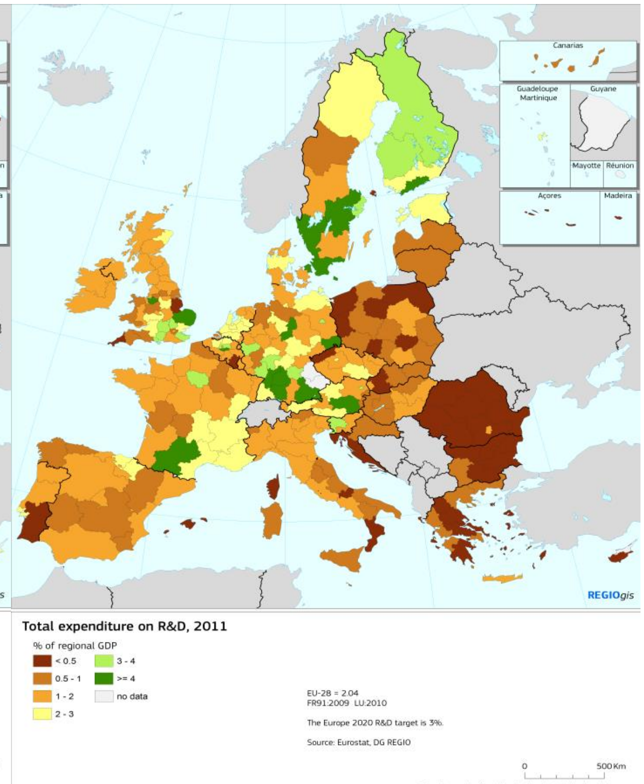


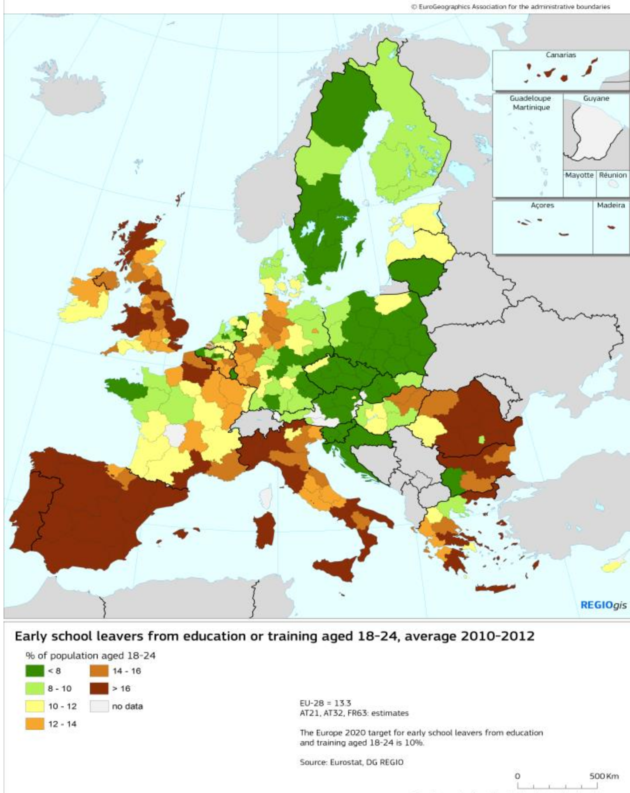
Figure 3: Graphing $\Delta y_{rEU2020}$ across countries and regions – reference year 2011

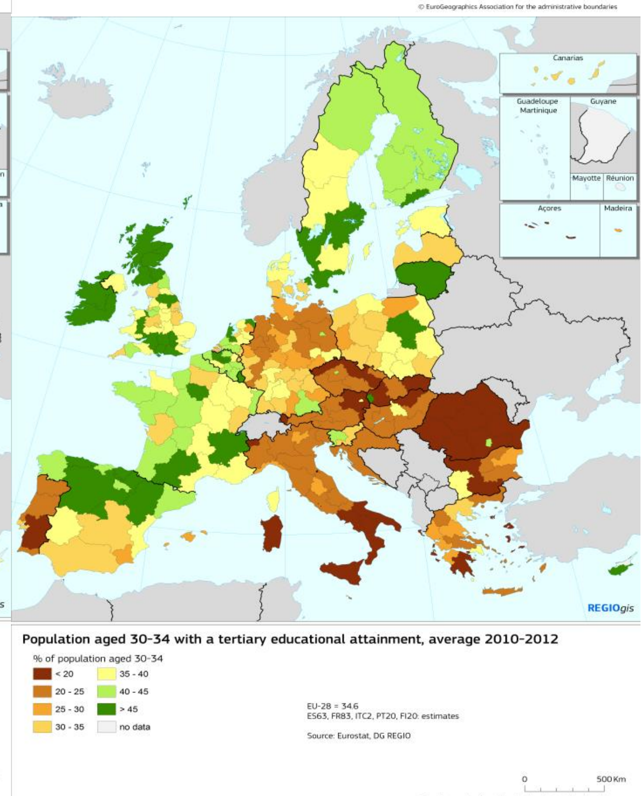
For completeness, Map 4 provides a component-wise breakdown of the index with common EU-28 targets. The broad trends we just discussed are once again apparent. Southern and central European countries tend to do worse than the core and the imposition of common targets lowers their performance in absolute terms. This pattern is not as applicable to the case of R&D, in which a number of regions in France, the UK, Germany, and Denmark do not perform very well.

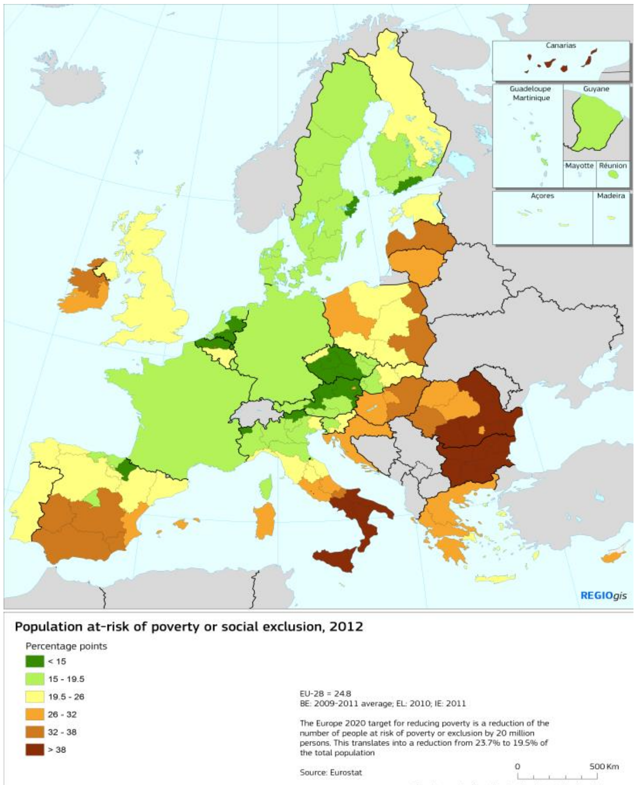
A2: Europe 2020 component maps










Canarias
Guadeloupe
Martinique
Guyane
Mayotte
Réunion
Açores
Madeira
REGIOgis
Population at-risk of poverty or social exclusion, 2012
Percentage points
< 15
15 - 19.5
19.5 - 26
26 - 32
32 - 38
> 38
EU-28 = 24.8
BE: 2009-2011 average; EL: 2010; IE: 2011
The Europe 2020 target for reducing poverty is a reduction of the number of people at risk of poverty or exclusion by 20 million persons. This translates into a reduction from 23.7% to 19.5% of the total population
Source: Eurostat
0
500 Km
© EuroGeographics Association for the administrative boundaries

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Abstract

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While we should be mindful not to overstate the reach of this analysis, a few general patterns are worth noting. First, we see that southern and central European countries such as Spain, Bulgaria, Greece, Portugal, Poland, Hungary and Romania fall behind Scandinavian and other northern European countries, despite the latters' more ambitious targets. Second, our analysis makes plain the significant inter-regional heterogeneity of Europe 2020 performance for many countries. The cases of Spain and Italy are particularly suggestive in this regard.

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