Statistics on Sustainable Development Goals in Europe

What should be done and what can be actually done

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Abstract. With the aim of monitoring progress towards sustainability, this work stresses the importance of setting precise thresholds levels of sustainability in each indicator adopted by United Nations. Moreover, due to missing data in Eurostat database, it highlights the difficulties and impossibility to monitor, over time, trends in sustainability of all European member countries. Chosen consequently year 2018 to perform analysis, it offers some statistics and considerations on the sustainability of European countries by means of a list of composite indices (one for each Sustainable Development Goal) whose indicators have been weighted by means of Spectral Value Decomposition technique.

Keywords: Sustainable Development Goals, Targets, Composite Indices.

1   Introduction

Sustainability is a complex and delicate concept involving all aspects of life; economic, social and environmental dimensions are jointly involved in the definition. Progress towards sustainability is a harder task than climate change fight, simply because the latter is included in its concept. Even if, in principle, we all wish that measures to promote sustainability will be taken in a more efficient way than those that are still ongoing for climate change, the reality is different, at least for the reasons that will be explained in the following. For more than 30 years scientists and policy makers have been debating on climate change issues, with no or low practical success. The same is happing with sustainability: since when the Agenda 21 has been adopted in 1992, passing through Millennium Development Goals (MDGs) adopted in 2000 and the 2030 Agenda for Sustainable Development adopted in 2015, with 17 SDGs and 169 targets at its core, no clear signal of success can be seen, simply because no precise threshold values[1] to monitor sustainability exist. While the Intergovernmental Panel on Climate Change (IPCC) clearly states a global warming target of 1.5 °C above pre-industrial levels, such precise thresholds values are missing in most SDGs and, more importantly,

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[1] The term *target* could generate confusion especially for statisticians; while in most cases the UN target's definition implies solely a "direction", its statistical definition requires instead the precise threshold value that should be reached in order to define the observation (country, region, etc.) sustainable. The author adopts the statistical definition of target.

in the indicators used to measure them. When a country, a region or city can be defined sustainable, remains consequently an open question.

The first part of this work offers (Section 2) the theoretical bases to measure exactly distance to target. Such recommendations become crucial in the construction of composite indices having this scope at its core. The second part, is devoted to the methodology applied to construct composite indices (Section 3) and main results derived (Section 4). Section 5 sums up and concludes.

2 Measuring distance to target

Most of the SDGs and, more importantly, their related indicators lack of precise quantitative threshold values to measure sustainability. This is a fundamental issue; it blinds not only researchers in their analysis but also policy makers whose policy recommendations should rely on the formers. However, a target is a necessary but not sufficient information: a second reference point is required to assess the *real* distance. This becomes mandatory especially when we are comparing several indicators expressed in different unit measures. The reason could be better explained looking at Figure 1, where a linear transformation is applied to map the raw data into a normalized scale [0,1]. Fixed a target value, the normalized distance to the target heavily depends on the inferior value chosen as maximum distance. This could be interpreted the *unsustainability* value. Consequently, when distance to target is the scope and main message of a composite index, the choice of the inferior point should not depend on the data set (for example the 2.5 percentile, average of the worst 5 values, etc.). The more the observations are homogeneous among them, i.e. cities or regions belonging to the same country, or countries with similar wellbeing level, the higher the probability of measuring biased distance.
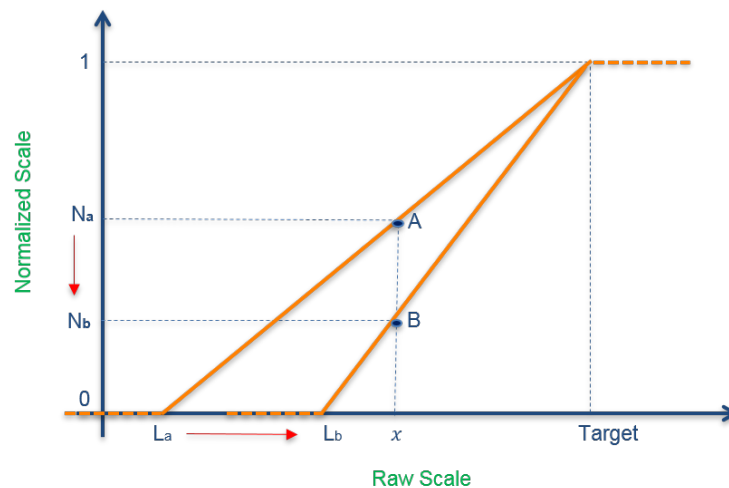

Figure 1 - Consequences of distance to target measurement as a function of inferior point

3 SDGs Composite Indices

Composite index is a useful tool to summarize huge amount of data and to set first policy recommendations based on the results obtained. Data normalization and criteria weighting are the main steps required. In this work, given the impossibility of measuring distance to target, input data have been standardized. Consequently, results do not represent the level of sustainability of a country per se, but a country performance respect the average of its peers.

The approach used to weight criteria (see Farnia, 2019) and reported in Subsection 3.2 relies on Spectral Value Decomposition (SVD), mathematical property of symmetric matrices at the base of Principal Component Analysis (PCA) and Factor Analysis (FA).

3.1 Eurostat Data base

Eurostat offers a special section on its website to SDGs data[2] freely available to users. The following analysis focuses on a subset of the available database: it covers 18 years (from 2000 to 2018[3]) and 40 European countries (27 Members countries, 5 EU candidate, 2 potential candidate, 4 European free trade association, 2 other European countries) and excludes, for comparison among countries, indicators and sub indicators belonging to Goal 14 (life below water). A total of 243 distinct indicators[4] and sub-indicator is available. Missing data (dark blue in Figure 2) represents the 46% of all potential information. Block of indicators, where no data is available for any years and countries, represents those indicators for which data is available only at aggregate Europe Level. A non-exhaustive list of indicators for which missing data represent the great majority of cases is reported in Table 1:

Table 1 - List of Eurostat database with at least 75% of missing data

Indicator	Eurostat Code
Perceived independence of the justice system	sdg_16_40
Climate related economic losses by type of event (only EU aggregate)	sdg_13_40
Consumption of chemicals by hazardousness (only EU aggregate)	sdg_12_10
Share of forest area	sdg_15_10
Smoking prevalence by sex	sdg_03_30
Soil sealing index	sdg_15_41
Grassland butterfly index - EU aggregate	sdg_15_61
Contrib. to the int. 100bn USD commit. on climate related expending	sdg_13_50
Recycling rate of waste excluding major mineral wastes	sdg_12_60
Surface of terrestrial sites designated under NATURA 2000	sdg_15_20

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[2] https://ec.europa.eu/eurostat/web/sdi/indicators
[3] At the time of writing too many missing data occur before 200 and after 2018.
[4] The count is net of repeating indicators due to their multi-scope characterization, i.e. they can be used to monitor more than one SDG.
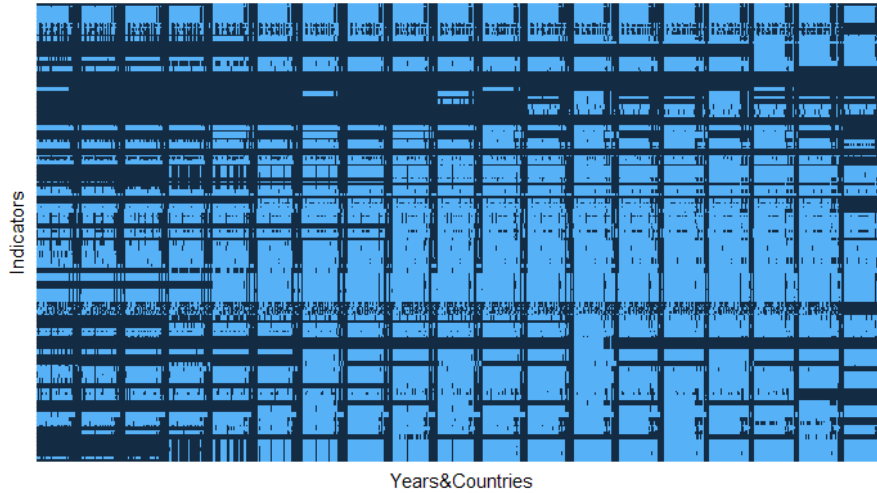
Figure 2 - SDGs missing values in Eurostat data base. (Missing values in dark blue; year 2000 to 2018 from left to right; SDG 1 to 17 from bottom to up)

Missing data makes it impossible to monitor over time indicators for EU 27 member countries too; year 2018 (see Table 4 in Appendix) is taken as reference year. Note however that indicators in Goal 15 and Goal 6, refer to the most recent and available year.

3.2   Criteria Weighting

It is mathematically proved (Wang and Stanley, 1970; Parulo et al., 2013) that not only heterogeneous variance among indicators plays a central role on the aggregated value, but also the degree of correlations among them. With this aim, in order to identify the latent structure of data, SVD has been applied clustering indicators within each Goal. The weights attached to them represent better the latent dimensions that data describe, favouring the ones that are statistically independent and, conversely, penalizing those that belong to the same latent dimension.

Consider a composite index formed by p indicators x_i with $i = \{1, 2, \dots p\}$, that have been previously adjusted according to their polarity and standardized. Denoting with $\mathbf{R}$ the correlation matrix, SVD allows to decompose the correlation matrix in the following way:

$$\mathbf{R} = \mathbf{A\Lambda A}' \tag{1}$$

where $\mathbf{\Lambda}$ $(p \times p)$ is the diagonal matrix of eigenvalues of $\mathbf{R}$ and $\mathbf{A} = \{a_{ij}\}$ $(p \times p)$ matrix of eigenvectors.

The way to retain the correct numbers of component and to weight them is based on Farnia (2019): the number of components to retain equals the number of eigenvalues greater than 1 and each component has the same weight. Mathematically, the weight vector $\mathbf{w}$ $(p \times 1)$ is computed as:

$$\mathbf{w} = \frac{1}{d}\mathbf{Bi} \tag{2}$$

where d represents the number of components retained, $\mathbf{B} = \{b_{ij} = a_{ij}^2\}$ $(p \times d)$ matrix where $j = 1, \ldots, d$ and $\mathbf{i}$ $(d \times 1)$ vector of ones.

For each country, its composite index y is hence a weighted average of the indicators belonging to it:

$$y = \mathbf{w}'\mathbf{x} \tag{3}$$

4   Results

Figure 4 to Figure 6 in Appendix graphically represent the performance of EU 27 members states and United Kingdom in each SDG. Countries whose performance is above/below average are represented in blue and red color respectively; the more a country performance is close to average, the more its color is close to white. Given the unevenly distribution of the number of indicators within Goal, data has been standardized again for comparison. Table 2 reports, for each SDG, countries whose performance is remarkably far from average, both positively and negatively; a variability of 2 is considered as criterion.

Table 2 - List of European countries having remarkably above/below average performance in year 2018

SDG	Remarkably Performance	
	Above	*Below*
Goal 1 - No poverty	-	-
Goal 2 - Zero hunger	Ireland	Malta
Goal 3 - Good health and well-being	Estonia	-
Goal 4 - Quality education	-	Italy, Romania
Goal 5 - Gender equality	Sweden	-
Goal 6 - Clean water and sanitation	-	Cyprus, Malta
Goal 7 - Affordable and clean energy	Denmark, Sweden	-
Goal 8 - Decent work and economic growth	-	Greece
Goal 9 - Industry, innovation and infrastructure	-	-
Goal 10 - Reduced inequalities	-	-
Goal 11 - Sustainable cities and communities	-	-
Goal 12 - Responsible consumption and production	Sweden	-
Goal 13 - Climate action	Sweden	-
Goal 15 - Life on land	-	Malta
Goal 16 - Peace, justice and strong institutions	-	Bulgaria
Goal 17 - Partnerships for the goals	Netherlands	-

Change of course would be recommended for Malta in Goal 2, Italy and Romania in Goal 4, Cyprus and Malta in Goal 6, Greece in Goal 8, Malta in Goal 15 and Bulgaria in Goal 16.

Figure 3 shows clusters and degree of dissimilarities[5] of European countries according to their performance in the 16 SDGs. Three/four macro clusters can be easily detected; they do not always correspond to geographical proximity.
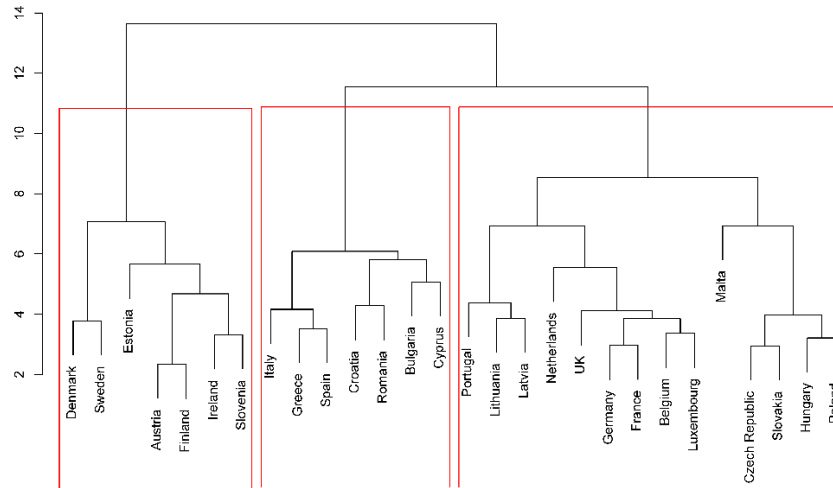

Figure 3 - Clusters of European countries in 2018 based on SDGs performance

Aggregating SDGs into a new synthetic measure and computing the overall influence (Wang and Stanley, 1970; Parulo et al., 2013) of each SDG in the composite index according to the following formula:

$$Influence_{x_i,y} = cor^2(x_i, y) \tag{4}$$

we obtain some useful information reported in Table 3: given the definition of sustainability, with SDGs as its core, and the existing tradeoffs among them, data seem to indicate that sustainability in Europe is mainly driven by *Peace, justice and strong institutions, Quality of education, Gender equality, Industry, innovation and infrastructure* to the detriment of *Life on land, Good health and well-being, Partnerships for the goals* and *Sustainable cities and communities*.

Table 3 - Relative importance of each SDG in EU 27 plus UK former member

SDG	Influence %
Goal 16 - Peace, justice and strong institutions	10.84
Goal 4 - Quality education	9.30
Goal 5 - Gender equality	9.06
Goal 9 - Industry, innovation and infrastructure	9.01
Goal 8 - Decent work and economic growth	8.95
Goal 7 - Affordable and clean energy	8.77
Goal 12 - Responsible consumption and production	8.62

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[5] According to Euclidean distance and Ward approach.

Goal 13 - Climate action	7.30
Goal 1 - No poverty	6.42
Goal 10 - Reduced inequalities	6.34
Goal 6 - Clean water and sanitation	5.53
Goal 2 - Zero hunger	5.43
Goal 11 - Sustainable cities and communities	2.11
Goal 17 - Partnerships for the goals	0.98
Goal 3 - Good health and well-being	0.92
Goal 15 - Life on land	0.43

5   Conclusions

Measuring sustainability requires not only the definition of precise targets but, at least, a second reference point, representing for example unsustainability, too. This hard task requires huge participation of scientists, policy makers and society; given the large number of indicators adopted by UN, it would take probably years if put in practice. Moreover, setting such reference points for all indicators would be, in some cases, unethical (see for example indicators that monitor health of people and for which unsustainable level of mortality needs to be defined). For this reason, it would be more appropriate and more efficient to concentrate the effort on a subset of key indicators to be monitored in time and space; increasing granularity, hence monitoring sub regional phenomena, should be the next important step.

Missing data is the second big issue to perform analysis, especially in the case of composite indices construction; Eurostat data base is not an exception. Analysis covering all 27 European member countries over time and for each SDG is impossible; more investment is required in data collection for Goal 6 and 15. Using year 2018 as reference year, the work identifies priorities for some European countries in specific SDG; at European level data suggest that progress toward sustainability is not occurring in harmonious way among SDGs; Peace, justice and strong institutions, Quality of education, Gender equality, Industry, innovation and infrastructure seem to be the priorities to the detriment of Life on land, Good health and well-being, Partnerships for the goals and Sustainable cities and communities.

References

1. Farnia, L. (2019), "On the Use of Spectral Value Decomposition for the Construction of Composite Indices". FEEM Working Paper No. 9.2019.
2. Parulo P., Saisana M. and Saltelli A. (2013), "Rating and Rankings: vodoo or science?" J. R. Statist. Soc. A, 176, 609-634.
3. Wang W., Stanley J. (1970), "Differential weighting: a review of methods and empirical studies". Rev. Educ. Res, 40, 663-705.

6   Appendix

Table 4 - List of indicators and sub indicators considered in each SDG

Goal	Indicator	Sub. Indicator	Code	Po-lar-ity
Goal 1 - No poverty	People at risk of poverty or social exclusion	T|TOTAL|PC	sdg_01_10	red
	People at risk of income poverty after social transfers	TOTAL|LI_R_MD60|T|PC	sdg_01_20	red
	Severely materially deprived people	GE4|T|TOTAL|PC	sdg_01_30	red
	People living in households with very low work intensity	T|Y_LT60|PC_Y_LT60	sdg_01_40	red
	In work at-risk-of-poverty rate	EMP|T|Y_GE18	sdg_01_41	red
	Population living in a dwelling with a leaking roof, damp walls, floors or foundation or rot in window frames of floor by poverty status	TOTAL|A_MD60|PC|T|TOTAL	sdg_01_60	red
		TOTAL|B_MD60|PC|T|TOTAL	sdg_01_60	red
	Self-reported unmet need for medical examination and care by sex	Y_GE16|F|TOOEFW|PC|TOTAL	sdg_03_60	red
		Y_GE16|M|TOOEFW|PC|TOTAL	sdg_03_60	red
	Population unable to keep home adequately warm by poverty status	TOTAL|A_MD60|PC	sdg_07_60	red
		TOTAL|B_MD60|PC	sdg_07_60	red
Goal 2 - Zero hunger	Agricultural factor income per annual work unit	I10	sdg_02_20	green
	Government support to agricultural research and development	NABS08|EUR_HAB	sdg_02_30	green
	Area under organic farming	PC_UAA|UAAXK0000|TOTAL	sdg_02_40	green
Goal 3 - Good health and well-being	Life expectancy at birth by sex	YR|F|Y_LT1	sdg_03_10	green
		YR|M|Y_LT1	sdg_03_10	green
	Share of people with good or very good perceived health by sex	PC|TOTAL|Y_GE16|F|VG_G	sdg_03_20	green
		PC|TOTAL|Y_GE16|M|VG_G	sdg_03_20	green
	Self-reported unmet need for medical examination and care by sex	Y_GE16|F|TOOEFW|PC|TOTAL	sdg_03_60	green
		Y_GE16|M|TOOEFW|PC|TOTAL	sdg_03_60	green
	Population living in households considering that they	TOTAL|A_MD60|PC	sdg_11_20	red
		TOTAL|B_MD60|PC	sdg_11_20	red

	suffer from noise, by poverty status			
Goal 4 - Quality education	Underachievement in reading, math or science	EF461|T|PC	sdg_04_40	red
		SCI|T|PC	sdg_04_40	red
	Early leavers from education and training by sex	PC|POP|Y18-24|F	sdg_04_10	red
		PC|POP|Y18-24|M	sdg_04_10	red
	Tertiary educational attainment by sex	F|Y30-34|PC|ED5-8	sdg_04_20	green
		M|Y30-34|PC|ED5-8	sdg_04_20	green
	Employment rates of recent graduates by sex	Y1-3|ED3-8|Y20-34|F|PC	sdg_04_50	green
		Y1-3|ED3-8|Y20-34|M|PC	sdg_04_50	green
	Young people neither in employment nor in education and training by sex	F|Y15-29|NO_FE_NO_NFE|NEMP|PC	sdg_08_20	red
		M|Y15-29|NO_FE_NO_NFE|NEMP|PC	sdg_08_20	red
Goal 5 - Gender equality	Seats held by women in national parliaments and governments	GOV_NAT|F|PC_WMN	sdg_05_50	green
		PARL_NAT|F|PC_WMN	sdg_05_50	green
	Positions held by women in senior management positions	BRD|F|PC	sdg_05_60	green
		EXEC|F|PC	sdg_05_60	green
	Gender employment gap	Y20-64|PC_POP|EMP_LFS	sdg_05_30	red
	Inactive population due to caring responsibilities by sex	FAMRESP|F|Y20-64|PC_INAC	sdg_05_40	red
	Early leavers from education and training by sex	PC|POP|Y18-24|F	sdg_04_10	red
	Tertiary educational attainment by sex	F|Y30-34|PC|ED5-8	sdg_04_20	green
	Employment rates of recent graduates by sex	Y1-3|ED3-8|Y20-34|F|PC	sdg_04_50	green
Goal 6 - Clean water and sanitation	Population connected to at least secondary wastewater treatment	WWT_GE2|PC	sdg_06_20	green
Goal 7 - Affordable and clean energy	Final energy consumption in households per capita	KGOE	sdg_07_20	red
	Energy productivity	PPS_KGOE|B1GQ	sdg_07_30	green
	Share of renewable energy in gross final energy consumption by sector	REN|PC	sdg_07_40	green
		REN_ELC|PC	sdg_07_40	green
		REN_HEAT_CL|PC	sdg_07_40	green
		REN_TRA|PC	sdg_07_40	green
	Energy import dependency by products	C0000X0350-0370|PC	sdg_07_50	red
		G3000|PC	sdg_07_50	red
		O4000XBIO|PC	sdg_07_50	red
		TOTAL|PC	sdg_07_50	red

|				
	Population unable to keep home adequately warm by poverty status	TOTAL|A_MD60|PC	sdg_07_60	red
		TOTAL|B_MD60|PC	sdg_07_60	red
Goal 8 - Decent work and economic growth	Long-term unemployment rate by sex	LTU|Y15-74|PC_ACT|F	sdg_08_40	red
		LTU|Y15-74|PC_ACT|M	sdg_08_40	red
	In work at-risk-of-poverty rate	EMP|T|Y_GE18	sdg_01_41	red
	Inactive population due to caring responsibilities by sex	FAMRESP|T|Y20-64|PC_INAC	sdg_05_40	red
	Resource productivity and domestic material consumption	EUR_KG_CLV10	sdg_12_20	green
	Real GDP per capita	CLV10_EUR_HAB|B1GQ	sdg_08_10	green
		CLV_PCH_PRE_HAB|B1GQ	sdg_08_10	green
	Young people neither in employment nor in education and training by sex	F|Y15-29|NO_FE_NO_NFE|NEMP|PC	sdg_08_20	red
		M|Y15-29|NO_FE_NO_NFE|NEMP|PC	sdg_08_20	red
Goal 9 - Industry, innovation and infrastructure	Gross domestic expenditure on R&D by sector	BES|PC_GDP	sdg_09_10	green
		GOV|PC_GDP	sdg_09_10	green
		HES|PC_GDP	sdg_09_10	green
		TOTAL|PC_GDP	sdg_09_10	green
	Employment in high- and medium-high technology manufacturing and knowledge-intensive services	PC_EMP|C_HTC_MH	sdg_09_20	green
		PC_EMP|KIS	sdg_09_20	green
	R&D personnel by sector	T|TOTAL|BES|PC_ACT_FTE	sdg_09_30	green
		T|TOTAL|GOV|PC_ACT_FTE	sdg_09_30	green
		T|TOTAL|HES|PC_ACT_FTE	sdg_09_30	green
	Average CO2 emissions per km from new passenger cars	None	sdg_12_30	red
Goal 10 - Reduced inequalities	Purchasing power adjusted GDP per capita	EXP_PPS_EU27_2019_HAB|GDP|PC	sdg_10_10	green
	Income distribution	TOTAL|T|RAT	sdg_10_41	red
	People at risk of income poverty after social transfers	TOTAL|LI_R_MD60|T|PC	sdg_01_20	red
Goal 11 - Sustainable cities and	Population living in households considering that they suffer from noise, by poverty status	TOTAL|A_MD60|PC	sdg_11_20	red
		TOTAL|B_MD60|PC	sdg_11_20	red
	Population living in a dwelling with a leaking	TOTAL|A_MD60|PC|T|TOTAL	sdg_01_60	red
		TOTAL|B_MD60|PC|T|TOTAL	sdg_01_60	red

com-muni-ties	roof, damp walls, floors or foundation or rot in window frames of floor by poverty status			
	Population reporting occurrence of crime, violence or vandalism in their area by poverty status	TOTAL|A_MD60|PC	sdg_16_20	red
		TOTAL|B_MD60|PC	sdg_16_20	red
Goal 12 - Responsible consumption and production	Energy productivity	PPS_KGOE|B1GQ	sdg_07_30	green
	Share of renewable energy in gross final energy consumption by sector	REN|PC	sdg_07_40	green
		REN_ELC|PC	sdg_07_40	green
		REN_HEAT_CL|PC	sdg_07_40	green
		REN_TRA|PC	sdg_07_40	green
	Resource productivity and domestic material consumption	EUR_KG_CLV10	sdg_12_20	green
	Average CO2 emissions per km from new passenger cars	None	sdg_12_30	red
Goal 13 - Climate action	Share of renewable energy in gross final energy consumption by sector	REN|PC	sdg_07_40	green
		REN_ELC|PC	sdg_07_40	green
		REN_HEAT_CL|PC	sdg_07_40	green
		REN_TRA|PC	sdg_07_40	green
	Average CO2 emissions per km from new passenger cars	None	sdg_12_30	red
Goal 15 - Life on land	Share Surface of terrestrial sites designated under NATURA 2000* (modified in share respect Eurostat)	TPA_KM2	sdg_15_20	green
	Share of forest area	PC|LCC1	sdg_15_10	green
		PC|LCC2	sdg_15_10	green
	Settlement area per capita	M2_HAB	sdg_11_31	red
	Soil sealing index	PC	sdg_15_41	red
	Estimated soil erosion by water - area affected by severe erosion rate	SEV|CLC2_3X331_332_335|PC	sdg_15_50	red
Goal 16 - Peace, justice and strong institutions	Population reporting occurrence of crime, violence or vandalism in their area by poverty status	TOTAL|A_MD60|PC	sdg_16_20	red
		TOTAL|B_MD60|PC	sdg_16_20	red
	General government total expenditure on law courts	EUR_HAB	sdg_16_30	green
	Perceived independence of the justice system	VBAD|PC	sdg_16_40	red
		VGOOD|PC	sdg_16_40	green

|	Corruption Perceptions Index	NR	sdg_16_50	green
Goal 17 - Partnerships for the goals	Per Capita EU imports from developing countries by country income groups	TOTAL|LDC|MIO_EUR	sdg_17_30	green
	General government gross debt	PC_GDP|S13|GD	sdg_17_40	red
	Shares of environmental and labor taxes in total tax revenues	ENV	sdg_17_50	green

Goal 1 - No poverty
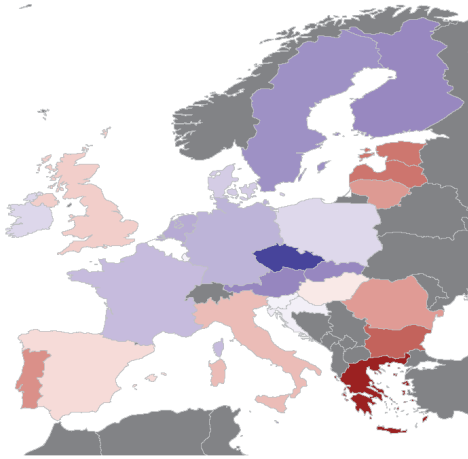
Goal 2 - Zero hunger
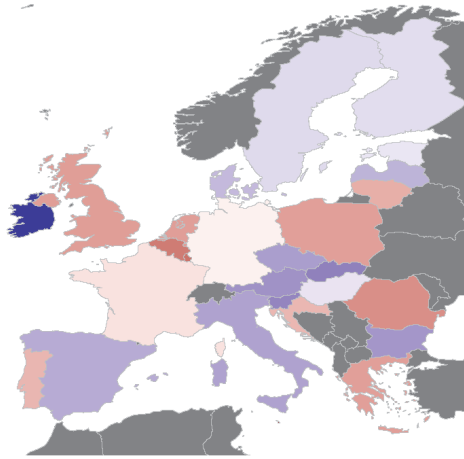
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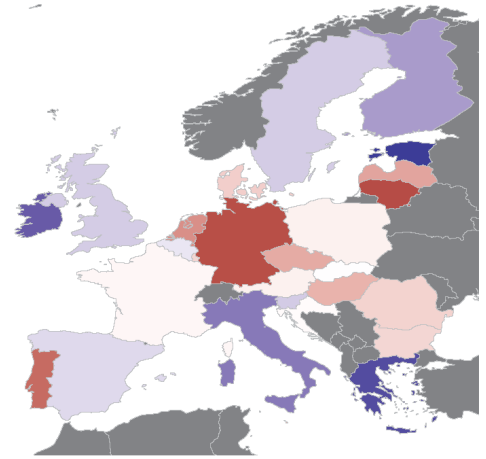
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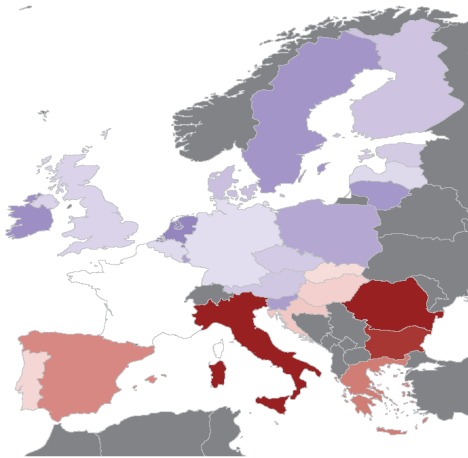
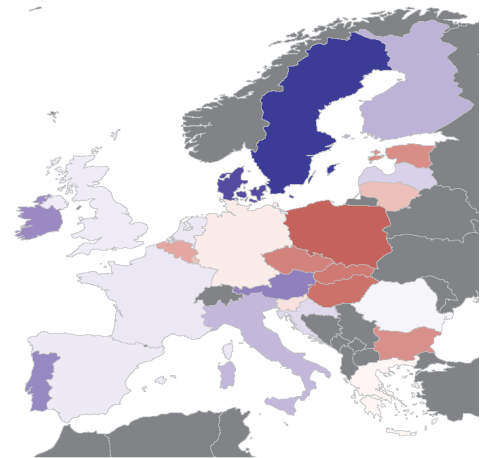Goal 5 - Gender equality
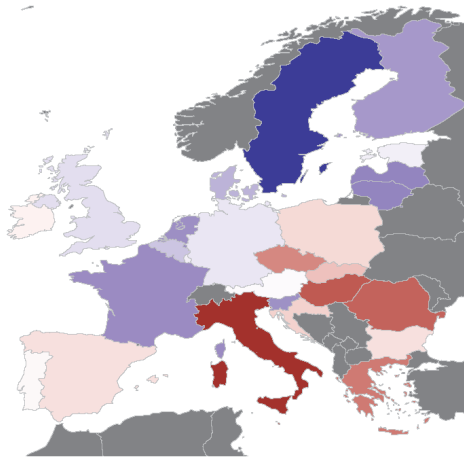
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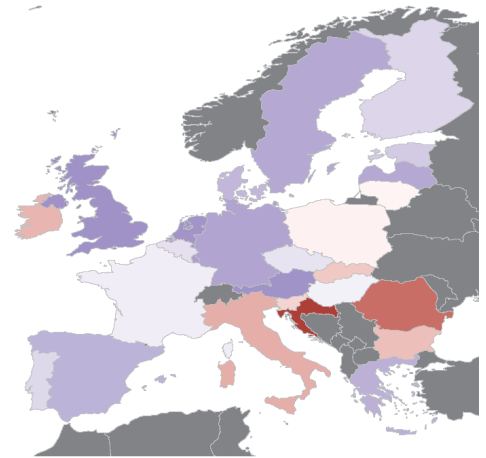
Figure 4 - European countries performances in 2018; SDG 1 to
6. Countries with remarkably above/below average

performance in dark blue/red; average performance in white;
countries not evaluated in grey

Goal 7 - Affordable and clean energy
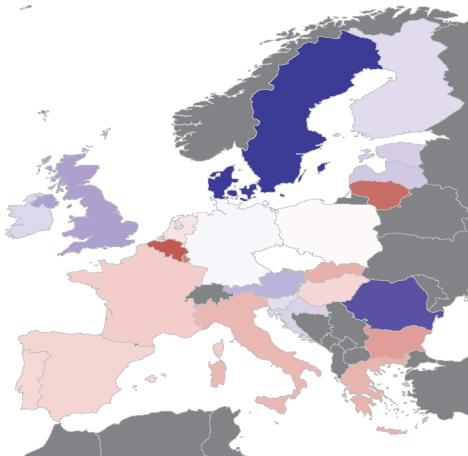
Goal 8 - Decent work and economic growth
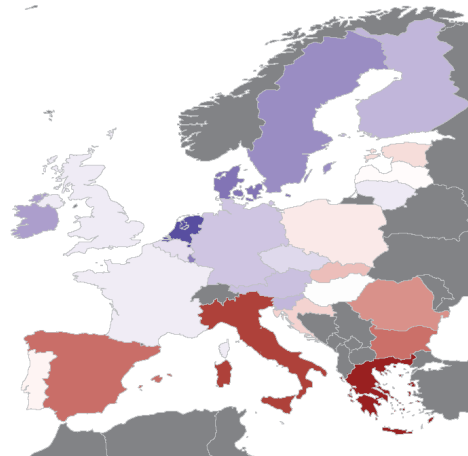
Goal 9 - Industry, innovation and infrastructure
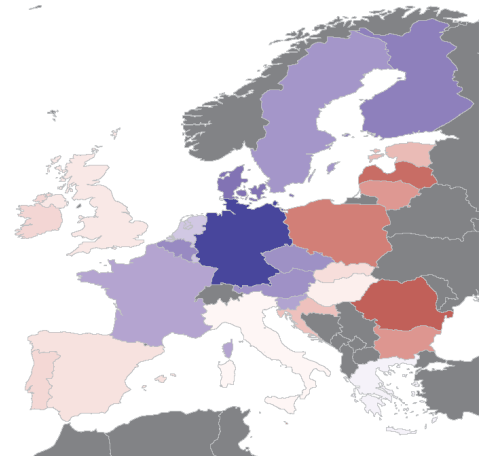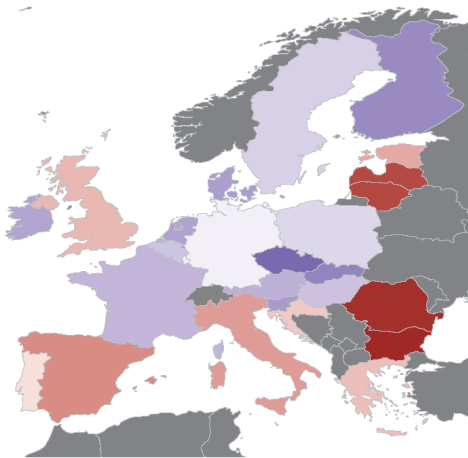
Goal 10 - Reduced inequalities

Goal 11 - Sustainable cities and communities
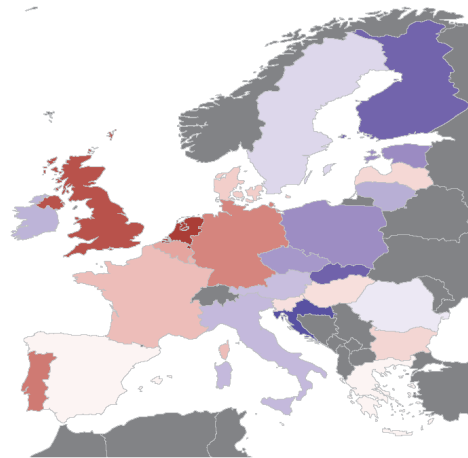
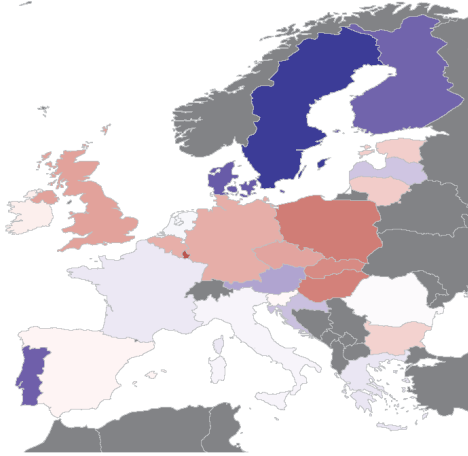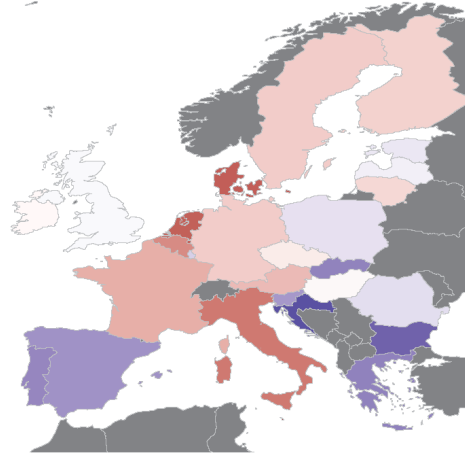Goal 12 - Responsible consumption and production

Figure 5 - European countries performances in 2018; SDG 7 to
12. Countries with remarkably above/below average perfor-
mance in dark blue/red; average performance in white; coun-
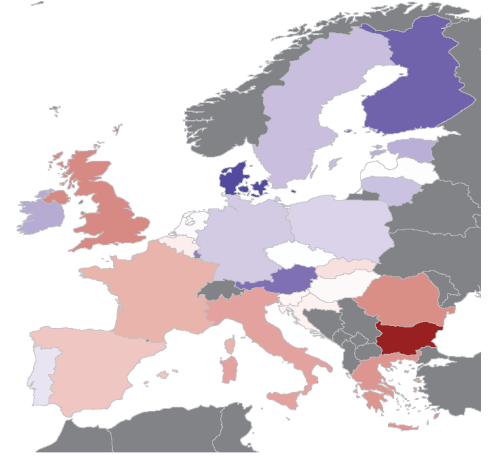tries not evaluated in grey

Goal 13 - Climate action

Goal 15 - Life on land

Goal 16 - Peace, justice and strong institutions
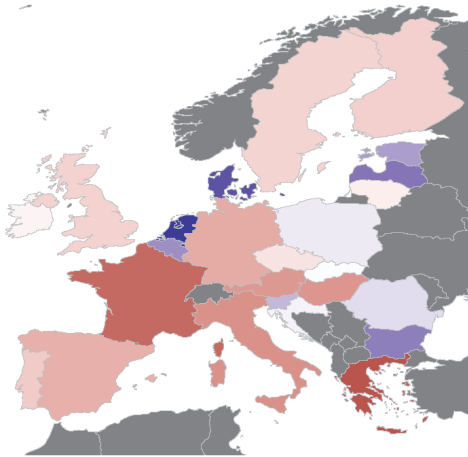

Goal 17 - Partnerships for the goals

Figure 6 - European countries performances in 2018; SDG 13 to 17. Countries with remarkably above/below average performance in dark blue/red; average performance in white; countries not evaluated in grey