Assessing progress towards SDGs implementation using the MRP-WSCI AND MRP-PCI multicriteria methods. The case study of the European countries

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1. Introduction

According to the UN Agenda 2030 and the Sustainable Development Goals, policy makers have to consider the sustainability perspective in strategic planning decisions. Identifying and measuring the level of sustainability, through its three dimensions, is a priority. This is the only way to understand if and how a Community, a Region, a Nation is on the path of sustainability. To achieve these objectives, Decision Makers need adequate technical support, since the basis of good decision-making rests on ex-ante evaluation, in progress monitoring and ex post evaluation. Sustainability is a multidimensional concept often represented by indicators of different nature, in which economic, social, and environmental aspects must be considered simultaneously; among assessment problems, that one of measuring sustainability is one of the most elaborated (Sala et al., 2015). Multi-criteria analysis methods appear suitable for this kind of appraisal and they have been extensively applied to it (Cinelli et al., 2014). As the sustainability assessment can be developed using many different approaches, the literature on this topic is growing, offering a wide range of possibilities (Ziemba, 2019), not suitable for all the applications but depending on the objectives, the scale and the scope of the analysis (Cinelli et al., 2014).
This study focuses on the application of the Multiple Reference Point Weak-Strong Composite Indicators (MRP-WSCI) and Multi Reference Point based Partially Compensatory Indicator (MRP-PCI), which are multicriteria analysis methods to obtain composite indicators through an aggregation procedure (Ruiz et al., 2020). Composite indicators are widely used in literature for analyzing ever-increasing amount of information (El Gibari et al., 2019). Different versions of these schemes have been already used to build composite sustainability indicators in Ruiz et al. (2011), Cabello et al. (2014, 2019,2020). In this case study, MRP-WSCI and WRP-PCI were used for the sustainability assessment of the 28 members of the European Union. The countries were analyzed and compared according to their own conditions and progress with respect to the 17 Sustainable Development Goals (SDGs) of Agenda 2030, considering their evolution over three reference years: 2007, 2012 and 2017.

2. Materials and Methods

2.1 MRP-WSCI and MRP-PCI

In this work, both the Multiple Reference Point Weak-Strong Composite Indicators (MRP-WSCI) and Multi Reference Point based Partially Compensatory Indicator (MRP-PCI) have been applied (Ruiz et al., 2011; 2019). These methods allow the construction of composite indicators, passing -implicitly or explicitly - through the phases of normalization (to bring all the indicators to the same scale), weighting (to assess the relative importance of each of the indicators) and aggregation (to build the final composite measure) (see, e.g., Saisana and Tarantola, 2002; El Gibari et al., 2019).

Both methods adopt a distance-based normalization scheme, which assumes that several reference levels are available for each indicator. These levels define certain performance bands, based on the ground of reservation and aspiration levels. Such reference levels can be established in two ways: they can be defined by one or a group of experts who provide a measure of the absolute performance of the indicators, or can be statistically set starting from a dataset. Through an achievement function and the reference levels, it is possible to normalize the criteria on the same scale and the normalized value indicates the position of each country with respect to the reference levels. Subsequently, there is the weighting phase. Both the methods do not require a specific way of assessing the weights for the indicators. Therefore, tradeoff weights must be given by the decision makers, using any of the existing methodologies.
The main difference between the two approaches is in the aspect of compensatory schemes. Compensation refers to the extent to which an unwanted result will be counterbalanced by other desirable results: full compensatory methods allow bad behaviors in some indicators to be compensated by good behaviors in others. On the other hand, non-compensatory methods do not allow this compensation to take place.
MRP-WSCI produces two types of composite indicators: the WCI (Weak Composite Indicator) and the SCI (Strong Composite Indicator). WCI allows for total compensation between indicators, which means that the worst performance in some indicators can be offset by the good performance of others. This provides a measure of the overall performance achieved by the indicators. On the contrary, the SCI does not allow any compensation. Therefore, it represents a measure of the worst performance achieved by an indicator, in relation to its weight. The two indicators can be combined, in the different aggregation phases. The Multi Reference Point based Partially Compensatory Indicator (MRP-PCI) is a partially compensatory variant of the MRP-WSCI methodology (Ruiz et al., 2019). Compared to the MRP-WSCI, the MRP-PCI allows different levels of compensation for each indicator: therefore, we have, at the same time, perfect, partial or nor compensation across criteria.

2.2 Case study

The purpose of this paper is to conduct a comparative sustainability analysis among the European Union member states, with reference to the objectives of Agenda 2030. The alternatives analyzed were the 28 Member States belonging to the European Union, before the Brexit (Figure 1). They were compared evaluating their progress according to the 2030 Agenda Sustainable Development Goals.

Figure 1: UE-28 Countries. Source: https://europa.eu/european-union/about-eu/

Agenda 2030 is a strategy adopted by the United Nations (UN) and entered into force in January 2016, replacing the previous Millennium Development Goals (MDGs) that had oriented the action in the period 2000-2015. It is an action program for people, the planet, prosperity, peace, and partnership that includes 17 goals (Figure 2) divided into 169 targets, which balance the three dimensions of sustainable development: economic growth, social inclusion, environmental protection.

Figure 2 Sustainable Development Goals (SDGs). Source: European Commission, 2019.

The EU commitment is to implement the Sustainable Development Goals both in its internal and external policies. To trace the progress in reaching the SDGs through the formulation of sound policies, an indicators-based monitoring system has been built. For each goal, some indicators for monitoring have been set in the Eurostat database (Figure 3).

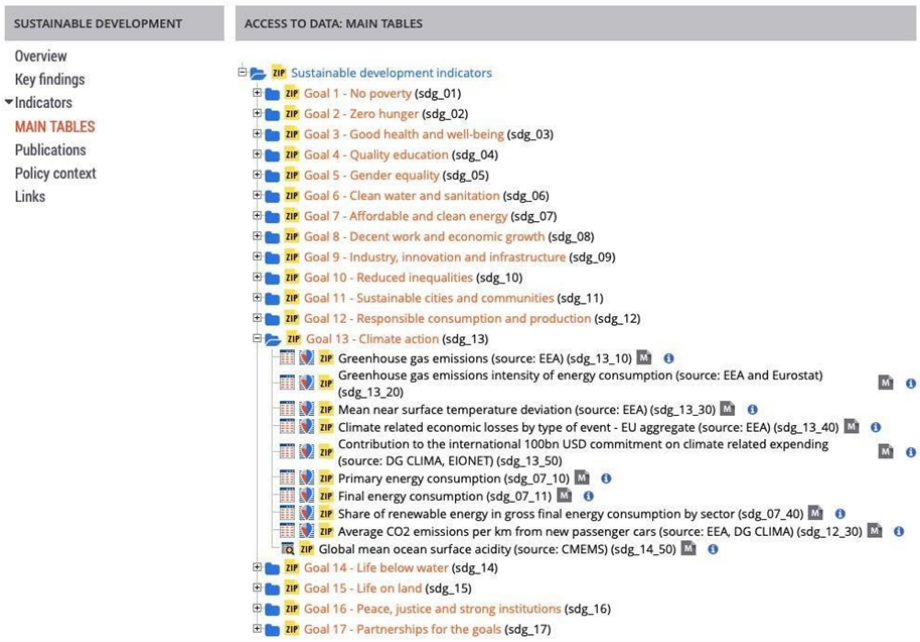

Figure 3: Sustainable development indicators database and list of indicators for Goal 13- Climate actions. Source: https://ec.europa.eu/eurostat/web/sdi/main-tables

For assessing the results of the EU member states according to the Agenda 2030, 40 indicators have been selected, covering the 17 goals (Table 1). All the chosen indicators are regarded as “significant” according to the document “Sustainable development in the European Union” (Eurostat, 2020) and are available in terms of data, for the time considered (years 2007-2012-2017).

GOALS	INDICATORS	units
Goal 1 – No poverty	1.1 – People at risk of poverty or social exclusion	%
	1.2 – People at risk of income poverty after social transfers	%
Goal 2 – Zero hunger	2.1 – Agricultural factor income per annual work unit	€/AWU
	2.2 – Government support to agricultural research and development	€ per capita
Goal 3 – Good health and well-being	3.1 – Life expectancy at birth	n
	3.2 – Share of people with good or very good perceived health	%
	3.3 – Self-reported unmet need for medical examination and care	%
Goal 4 – Quality education	4.1 – Early leavers from education and training	%
	4.2 – Employment rates of recent graduates	%
	4.3 – Adult participation in learning	%
Goal 5 – Gender equality	5.1 – Gender pay gap in unadjusted form	%
	5.2 – Gender employment gap	%
	5.3 – Positions held by women in senior management positions	%
Goal 6 – Clean water and sanitation	6.1 – Population having neither a bath, nor a shower, nor indoor flushing toilet in their household by poverty status	%
Goal 7 – Affordable and clean energy	7.1 – Primary energy consumption	MTEP
	7.2 – Energy productivity	KGOE
	7.3 – Share of renewable energy in gross final energy consumption	%
Goal 8 – Decent work and economic growth	8.1 – Real GDP	€ per capita
	8.2 – Employment rate	%
	8.3 – People killed in accidents at work	per 100 000 persons in employment
Goal 9 – Industry, innovation and infrastructure	9.1 – Gross domestic expenditure on R&D by sector	%
	9.2 – Share of busses and trains in total passenger transport	%
Goal 10 – Reduced inequalities	10.1 – Purchasing power adjusted GDP	%
	10.2 – Relative median at-risk-of-poverty gap	%
Goal 11– Sustainable cities and communities	11.1 – Overcrowding rate by poverty status	%
	11.2 – Exposure to air pollution by particulate matter	µg/m3
	11.3 – Recycling rate of municipal waste	%
Goal 12 – Responsible consumption and production	12.1 – Circular material use rate	% of material input for domestic use
	12.2– Resource productivity and domestic material consumption	PPS (Purchasing power standard) per Kg
Goal 13 – Climate action	13.1 – Greenhouse gas emissions	Co2 Teq
	13.2 – Average CO2 emissions per km from new passenger cars	g Co2/Km
Goal 14 – Life below water	14.1 – Bathing sites with excellent water quality	%
	14.2 – Surface of marine sites designated under Natura 2000	Km2
Goal 15 – Life on land	15.1 – Surface of terrestrial sites designated under Natura 2000	%
	15.2 – Soil sealing index	%
Goal 16 – Peace, justice and strong institutions	16.1 – Population reporting occurrence of crime, violence or vandalism in their area by poverty status	%
	16.2 – Corruption Perceptions Index	0-100
	16.3 – Population with confidence in EU institutions	%
Goal 17 – Partnerships for the goals	17.1 – EU imports from developing countries	000 €
	17.2 – General government gross debt	%

Table 1: Goals and indicators considered in the analysis.

For the calculation of the composite indicators, it is necessary to determine the reference levels q_i which define the performance of each indicator in relation to the Goal in which it is included. In addition to the minimum (Min) and maximum (Max) values, three other intermediate levels corresponding to the percentiles 25 (P25), 50 (P50) and 75 (P75) have been statistically fixed. Consequently, the results will show the relative position of each country with respect to all the EU-28 countries. In particular, to evaluate the dispersion of data and identify any outliers, a scatter plot was created for each indicator and each year (Figure 4).

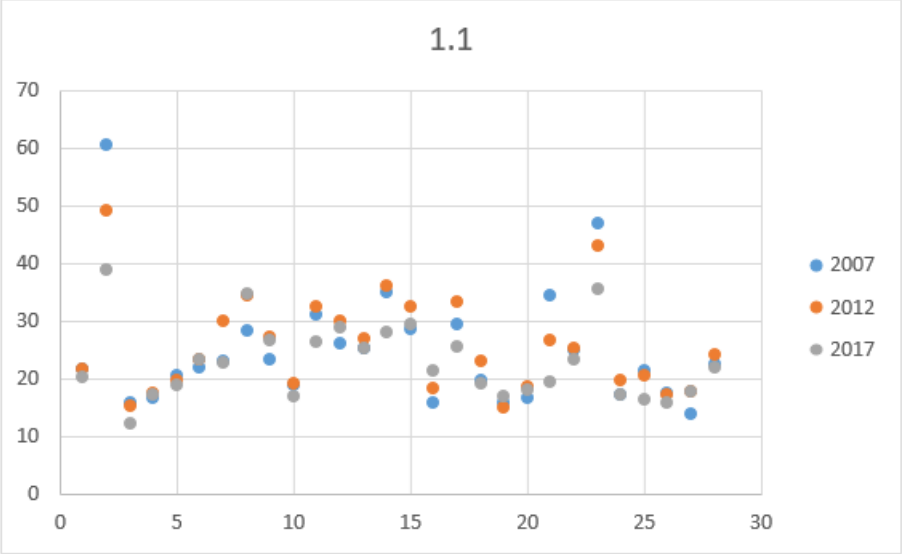

Figure 4 - Scatter plot for indicator 1.1 - People at risk of poverty or social exclusion (%).

Figure 5 reports an example for indicator 1.1 of all the information needed in the analysis: the data for each country and the statistical values identified as minimum, maximum and percentiles (P25-P-50-P75) for each year.

Normalization has been done according to the achievement function, based on a common default scale defined by values α^t from 0 to 4: α^t values and the corresponding levels of sustainability are reported in Table 2.

	2007	2012	2017
Belgium	21.6	21.6	20.3
Bulgaria	60.7	49.3	38.9
Czechia	15.8	15.4	12.2
Denmark	16.8	17.5	17.2
Germany	20.6	19.6	19
Estonia	22	23.4	23.4
Ireland	23.1	30.1	22.7
Greece	28.3	34.6	34.8
Spain	23.3	27.2	26.6
France	19	19.1	17
Croatia	31.1	32.6	26.4
Italy	26	29.9	28.9
Cyprus	25.2	27.1	25.2
Latvia	35.1	36.2	28.2
Lithuania	28.7	32.5	29.6
Luxembourg	15.9	18.4	21.5
Hungary	29.4	33.5	25.6
Malta	19.7	23.1	19.3
Netherlands	15.7	15	17
Austria	16.7	18.5	18.1
Poland	34.4	26.7	19.5
Portugal	25	25.3	23.3
Romania	47	43.2	35.7
Slovenia	17.1	19.6	17.1
Slovakia	21.4	20.5	16.3
Finland	17.4	17.2	15.7
Sweden	13.9	17.7	17.7
United Kingdom	22.6	24.1	22

2007		
q^0	Min	-60.7
q^1	P25	-28.4
q^2	P50	-22.3
q^3	P75	-17.3
q^4	Max	-13.9
2012		
q^0	Min	-49.3
q^1	P25	-30.7
q^2	P50	-23.8
q^3	P75	-19.0
q^4	Max	-15.0
2017		
q^0	Min	-38.9
q^1	P25	-26.5
q^2	P50	-21.8
q^3	P75	-17.6
q^4	Max	-12.2

Figure 5 - Example for indicator 1.1 - People at risk of poverty or social exclusion: data for each year and reference levels

Interval	Level of sustainability
$0 \leq \alpha \leq 1$	Insufficient
$1 < \alpha \leq 2$	Sufficient
$2 < \alpha \leq 3$	Good
$3 < \alpha \leq 4$	Excellent

Table 2 achievement function and level of sustainability

Indicators have been aggregated in three levels. First aggregation level is among indicators, for having one index for each sustainable development goal. Then, each of the 17 SDGs has been classified in one of the three dimensions of sustainability (Economic, Environmental, Social) and the aggregation has been done within each dimension. Finally, the three dimensions of sustainability have been aggregated in a global sustainability index. The three aggregations have been repeated for the three reference years (2007, 2012, 2017) for each EU member (Figure 6), both applying the MRP-WSCI and MRP-PCI schemes.

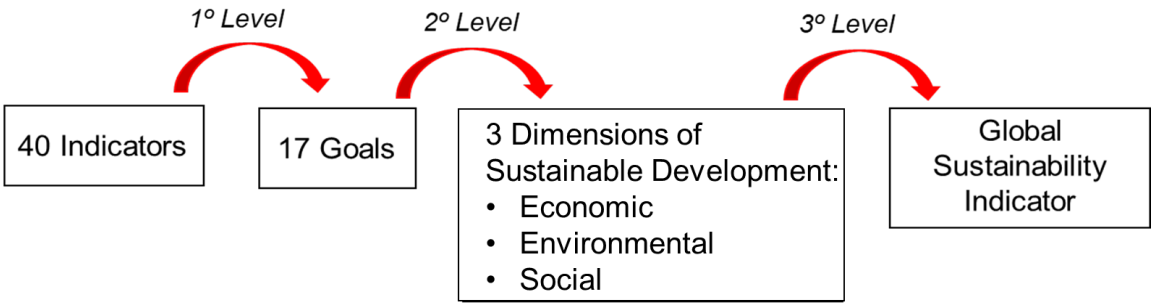

Figure 6: Aggregation steps for each EU Member and for each year considered (2007-2012-2017).

The weighting phase has been carried out trying to assess the contribution of each indicator and goal to the final global value (Table 3), considering three EU documents:

- Europe 2020: A strategy for smart, sustainable and inclusive growth.
- A Union that strives for more" Ursula Von Der Leyen electoral agenda.
- Budget proposal for the 2021-2027 and new cohesion policy[1] (May 2018).

Assessment	Value
Not very important	1
Important	2
Very important	3

Table 3: weights scale

The results of the weighting phase and all the weights used in the analysis are reported in Figure 7, along with the aggregation scheme.

[1] https://ec.europa.eu/commission/future-europe/eu-budget-future_en

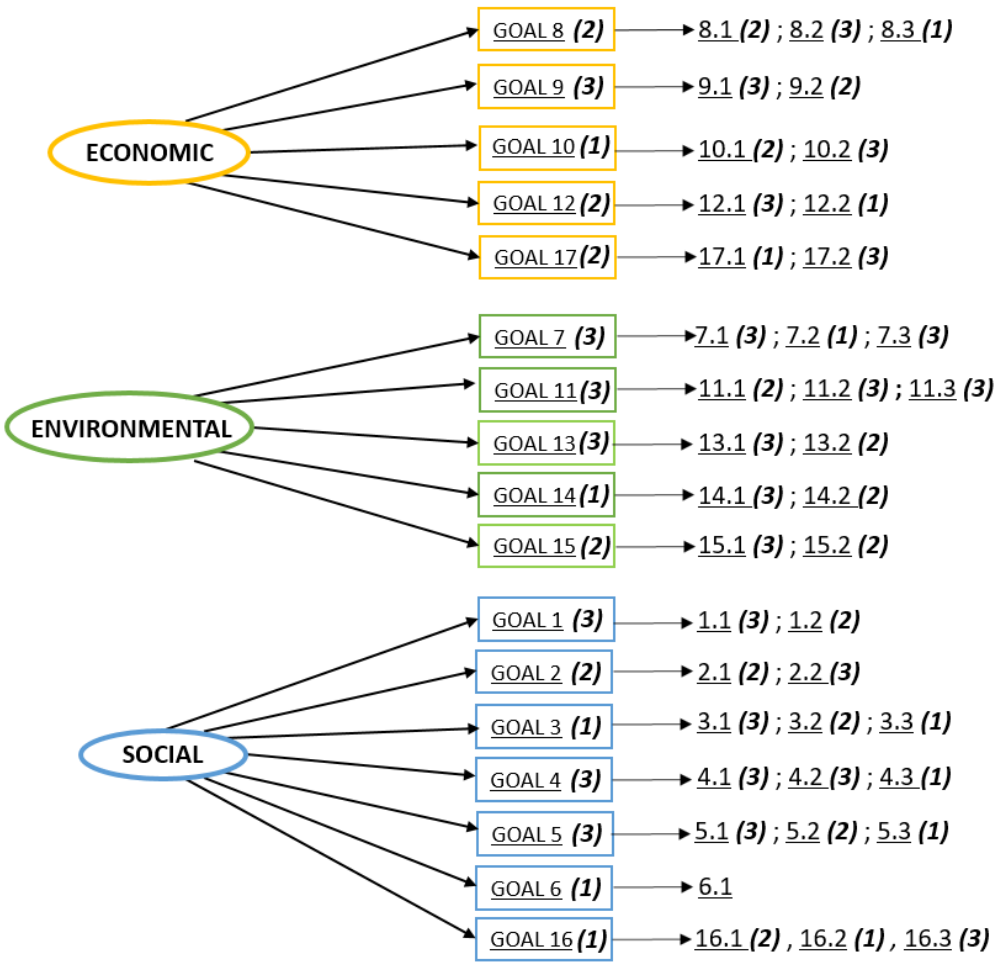

Figure 7 - Weights used in the analysis and aggregation scheme.

The same aggregation scheme and weights have been used for applying the MRP-WSCI scheme, producing both a Weak-Weak-Weak (W-W-W) and Strong-Weak-Weak (S-W-W) global composite indicators, and for the MRP-PCI scheme, calculating a global Partially Compensatory Composite Indicator.

4. Results and discussion

4.1 Weak-Weak-Weak (W-W-W) and Strong-Weak-Weak (S-W-W) global composite indicators

The Weak-Weak-Weak Global Composite Indicator (W-W-W) and the Strong-Weak-Weak (S-W-W) are global composite indices derived by the third and last aggregation steps of the application of MRP-WSCI. In the W-W-W the Weak Composite Indicator (WCI) has been applied in each aggregation step, while in the S-W-W the Strong Composite Indicator (SCI) was applied in the last step. Therefore, the W-W-W represents a measure of global compensation: it gives us a value that is the result of the average between the three dimensions of sustainable development, namely economic, social, and environmental ones. The S-W-W, on the other hand, identifies the worst sustainability dimension.

Running both the indices is very advantageous, as it provides an image of the global sustainability, but also allows to access a specific dimension. Moreover, very often the W-W-W shows good performance that depend on just two dimensions, while the third dimension has bad levels.

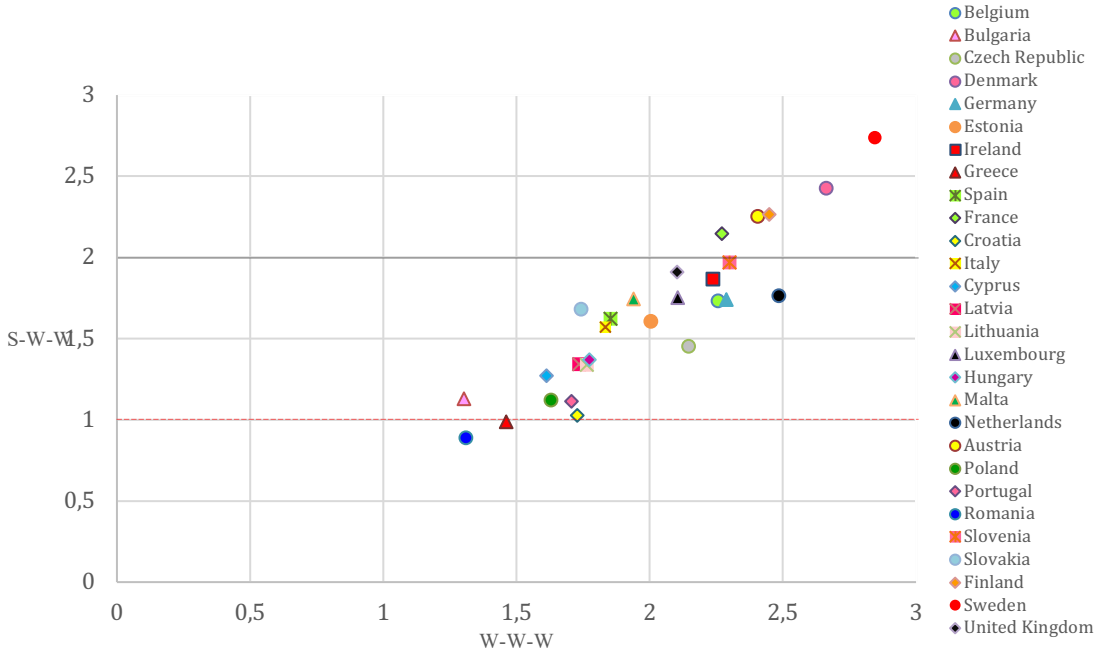

Figure 8: EU member states joint results 2017

Figure 8 reports at the same time the results of the W-W-W (x axis) and of the S-W-W (y axis) for the different EU countries. Considering the common scale, results show the position with respect to the reference levels:

- Over percentile 75 if they are greater than 3;
- Between percentiles 50 and 75 ¡, if they are between 2 and 3;
- Between percentiles 25 and 50 ¡, if they are between 1 and 2;
- Under percentile 25, if they are less than 1.

-

Given this classification, Figure 8 is divided into four quadrants by the value 2, while the red line at the value of 1 indicates the states that are below the sufficiency for the value of S-W-W. Figure 8 gives a general idea of which countries have a good overall result and those which haven't. The analysis will be more detailed below and the EU states will be analyzed according to their positioning on the chart.

Then, based on the references scale and the quadrant division, we can classify the states in 4 groups:

- First quadrant: States with an excellent level of sustainability (both W-W-W and S-W-W are between percentiles 50 and 75¡)
- Second Quadrant: States with a good level of sustainability (only W-W-W is between percentiles 50 and 75¡)

- Third Quadrant: States with a sufficient level of sustainability (both W-W-W and S-W-W are between percentiles 25 and 50¡; W-W-W is over 1.5)
- Forth quadrant: States with an insufficient level of sustainability (only W-W-W is between percentiles 25 and 50¡; S-W-W is under percentile 25)

4.1.1 First quadrant: States with an excellent level of sustainability

Sweden, Denmark, Finland, Austria, and France are in the first quadrant and therefore they performed well, considering both the global W-W-W and the S-W-W indicators. Furthermore, considering the timing, Sweden, Austria, and France have also improved or maintained the value of the global W-W-W indicator in the 2007-2017 decade (Figure 9), whilst the same does not apply to Finland and Denmark.

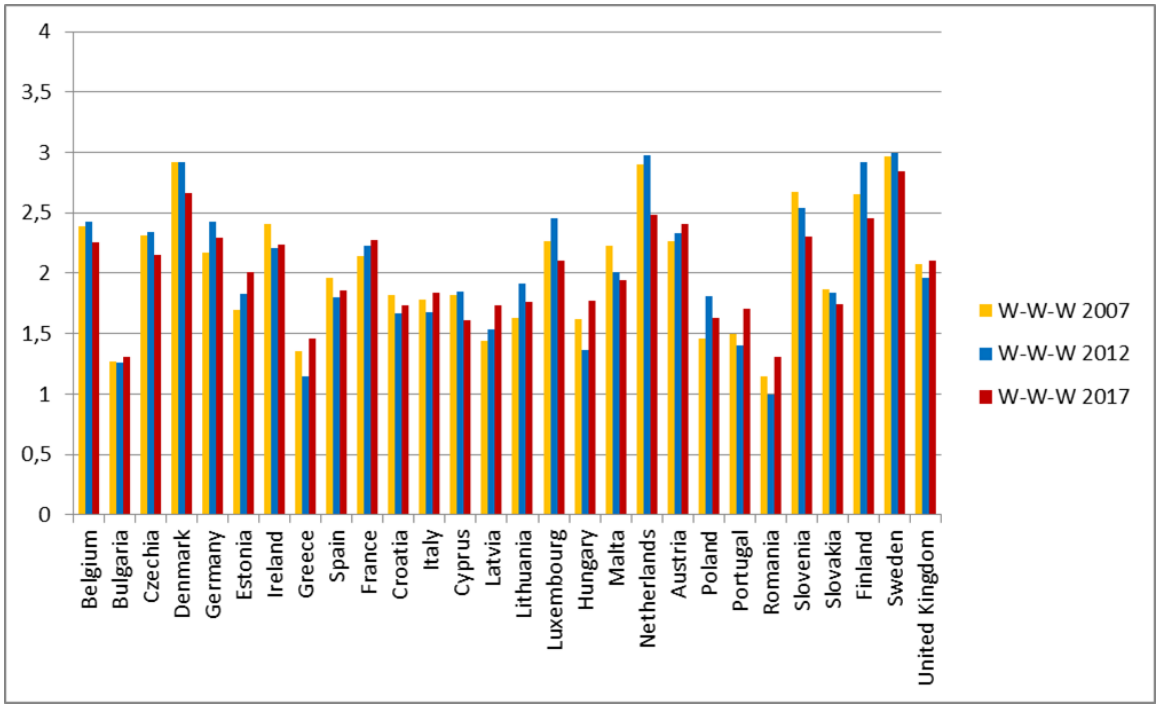

Figure 9: Global sustainability index W-W-W 2007, 2012, 2017.

Finland's worsening is mainly due to the reduction in the values of the economic dimension between 2012 and 2017 (Figure 10), while for Denmark the decrease is mainly due to the social dimension (Figure 11).

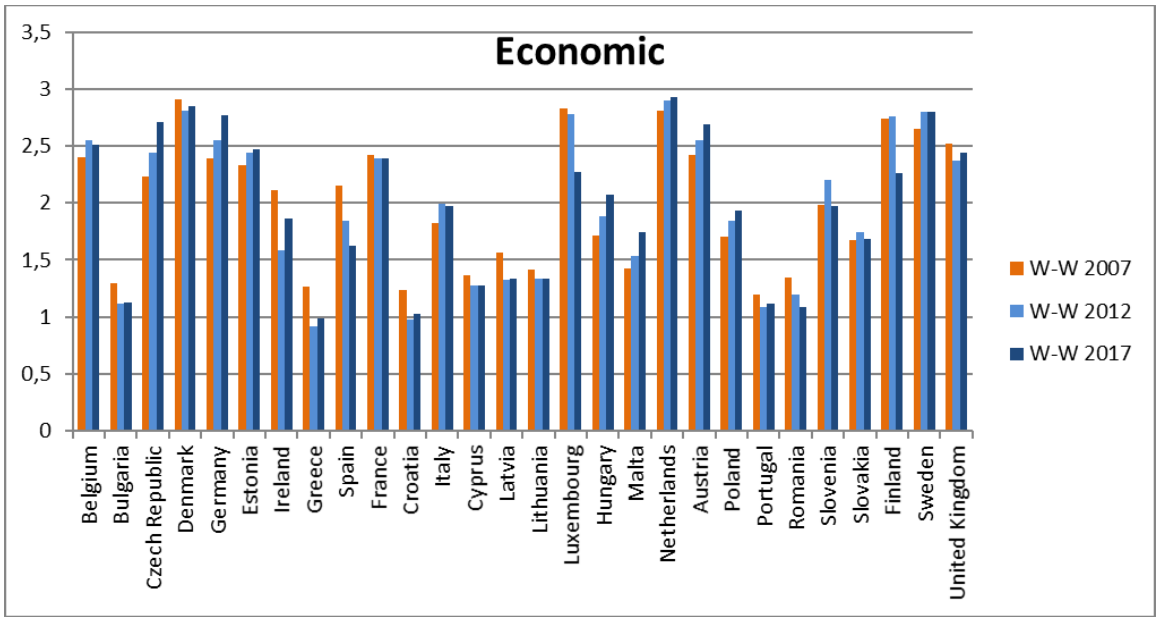

Figure 10: Economic Sustainability index W-W 2007, 2012, 2017.

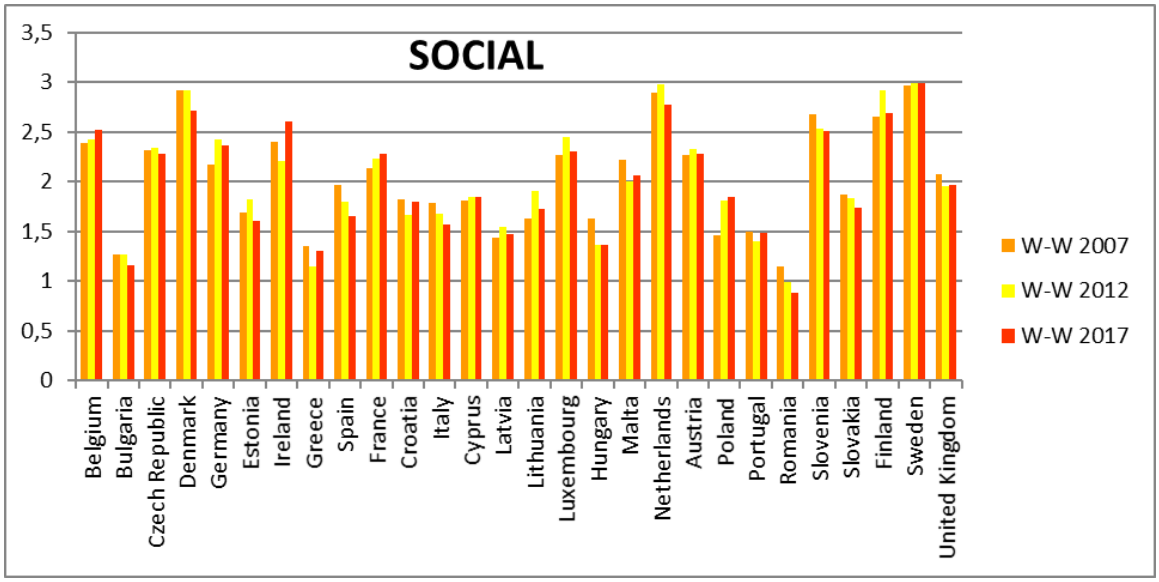

Figure 11: Social Sustainability index W-W 2007, 2012, 2017.

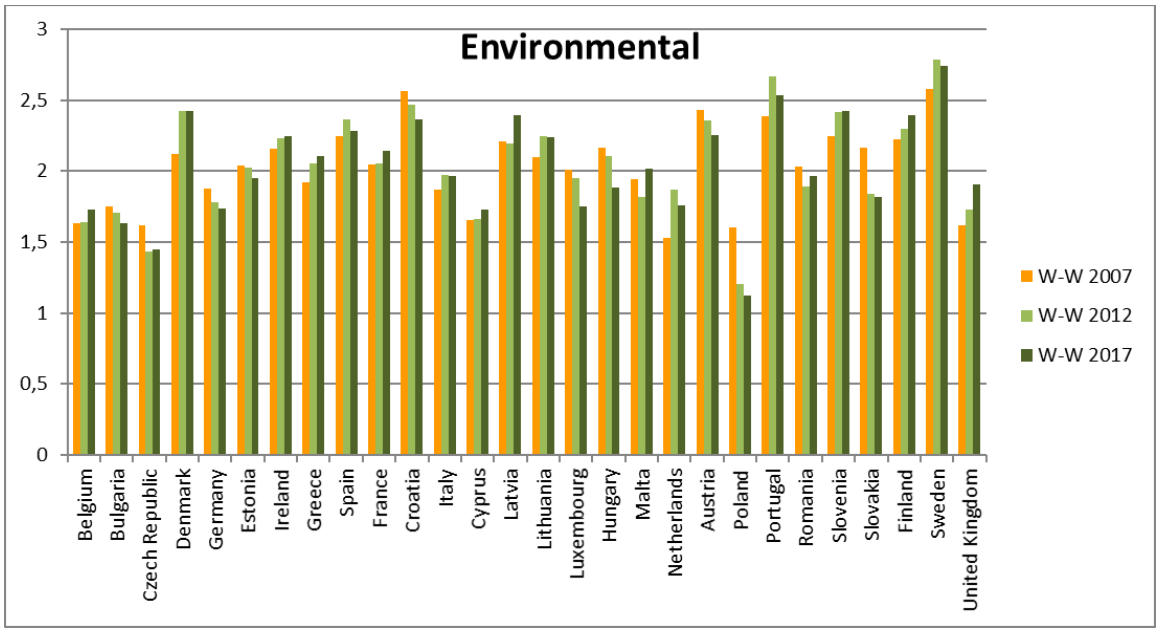

Figure 12: Environmental Sustainability index W-W 2007, 2012, 2017.

4.1.2 Second Quadrant: States with a good level of sustainability

The Netherlands, Ireland, Slovenia, Germany, Belgium, United Kingdom, Luxembourg, Czech Republic, and Estonia are in the second quadrant (Figure 8). The value of the global indicator W-W-W is greater than 2 and they are also sufficient according to the S-W-W. However, values of S-W-W below 2 highlight difficulties at the level of one or more dimensions. For instance, Figure 8 shows that the Netherlands have a better global index than Austria and Finland, but certainly a value of one of the dimensions is not good. This is also confirmed by Figure 13 (W-W Composite sustainability indicator for the three sustainability dimensions), in which we see that the values of the economic and social dimensions are more than good, but that of the environmental dimension is below 2.

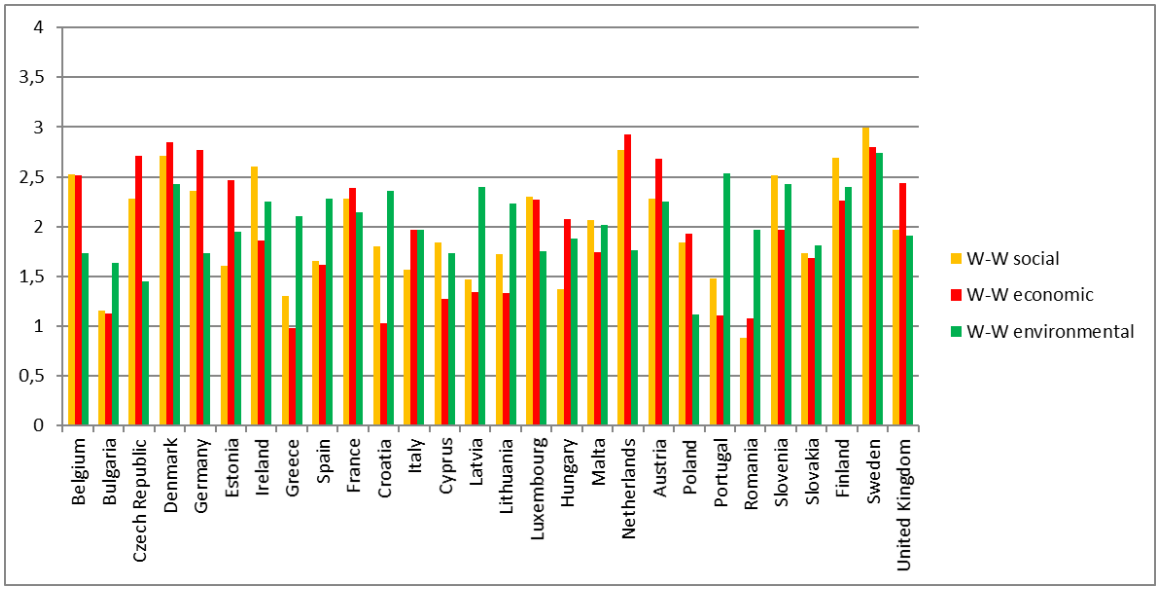

Figure 13: Composite sustainability indices for the three dimensions, 2017

The Czech Republic also has a low value of the environmental W-W composite indicator, which represents a measure of global compensation, especially when compared to those of the other dimensions (Figure 13).
For Luxembourg, the 2017 values of the three dimensions are not worrying, even if the environmental one is not considered good (Figure 13). However, the decrease in the value of the W-W-W over the years has to be considered carefully (Figure 9). The drop in values over the years is noted above all for the economic (Figure 10) and environmental (Figure 12) dimensions.
Germany and Belgium have a low value regarding the environmental dimensions (Figure 12). Germany has a value of the environmental indicator W-W equal to 1.73, which is under the good level, even if the objectives reach all sufficient values, apart from GOAL 13 - Fight against climate change, which has both indicators at a level less than 1. Also, Belgium, like Germany, has the W-W value equal to 1.73 in the environmental sphere, below the good threshold.
Estonia's global indicator of the social dimension (Figure 11) has a very low value compared to the other two dimensions. Only two objectives have good values, while all the others are just sufficient, and one is insufficient.
Ireland and Slovenia have values below 2 only for the economic dimension, while the United Kingdom for the social and environmental dimension (Figure 13).

4.1.3 Third Quadrant: States with a sufficient level of sustainability

Malta, Italy, Spain, Slovakia, Hungary, Latvia, Lithuania, Cyprus, Poland, Portugal, Bulgaria, Croatia, Greece, are located on the third quadrant and have a low value both of the global composite indicators W-W-W and S-W-W. From this it can be deduced that these States have a bad value, i.e. below 2, for more dimensions.
Malta, Italy, Spain, and Slovakia have no dimensions less than 1.5 (Figure 13), therefore they are at least sufficient. In addition, as noted in Figure 9, Malta has improved over the past decade, while Spain and Slovakia have worsened, and Italy has not seen major changes.
Hungary, Latvia, Lithuania, Cyprus, Poland, Portugal and Croatia have W-W-W values greater than 1.5, while S-W-W values are between 1 and 1.5. As for Croatia, Cyprus, Lithuania, Latvia and Portugal, the lowest value is reached by the economic W-W (Figure 13), while Hungary holds the worst results in the social dimension and Poland in the environmental one.

4.1.4 States with an insufficient level of sustainability

Bulgaria, Greece and Romania are the countries that are in the worst situation. They are in the third quadrant and they exhibit the lowest values for both indicators (Figure 8). In particular, Romania and Greece have one or more dimensions below the sufficiency threshold considered. Furthermore, we can see (Figure 13) how the problem is mainly at the level of the economic and social spheres, while Greece reaches good levels for the environmental dimension and other three states show an environmental W-W above 1.5.

4.2 Partially Compensatory Composite Indicator: no compensation

The Partially Compensatory Composite Indicators obtained in each aggregation phase were used as an achievement function to determine the composite indicator of the next step. In particular, for the PCI, in each step a compensation index λ_i was provided. λ_i ranges between 0 and 1, according to the degree of compensation:

- $\lambda_i = 1$, perfect compensation among indicators
- $\lambda_i = 0.5$, average compensation among Goals
- $\lambda_i = 0$, according to strong sustainability, no compensation is allowed among the three dimensions.

The results presented are about the last aggregation. By applying a compensation index of 0 in this phase, which means not compensation at all, the result obtained reflects the worst value achieved by one of the three dimensions of sustainability. Therefore, the lower the values of the dimensions, the more they affect the final measure of the PCI. As the common scale goes from 0 to 4, if a member state is in the range from 0 to 1, it presents an unsustainable situation; in interval between 1 and 2, countries are on the threshold of sustainability sufficiency; between 2 and 3 there is a good level of sustainability and, finally, if the value is greater than 3 the state has an optimal level of sustainability. According to the principles of strong sustainability, the three dimensions have the same weight.
Analyzing the decade considered (Figure 14), most of the States resulted in a global PCI between 1 and 2 with many fluctuating trends. Therefore, there is a sufficient level of sustainability among countries, although the situation is still far from an optimum. A value greater than 2 was achieved only by Sweden in 2017 (2.24), while above 1.5 there are Austria, Finland, Slovenia, France, and Denmark. Belgium, Malta, the United Kingdom, Finland, and Austria have progressively improved over the decade. On the contrary, Germany and Spain showed a significant and progressive deterioration. Lithuania, Cyprus, Croatia, Portugal, Greece, Bulgaria, and Romania closed the considered period with a value below 1 in 2017. It should be noted that those last two countries achieved the worst values, which are 0.79 and 0.55, respectively.

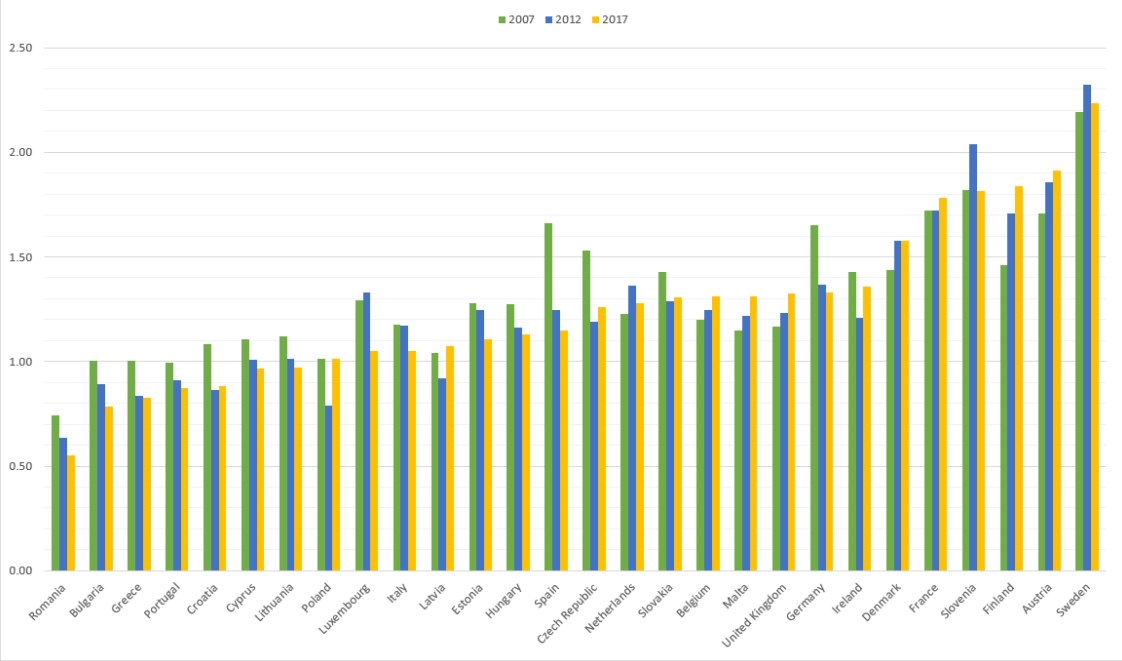

Figure 14: Global PCI over years

As the global PCI of each State reflects the value of the worst dimension among the three, it is possible to divide in groups the countries. For Belgium, Czech Republic, Denmark,

Germany, Estonia, France, Luxembourg, Malta, Holland, Poland, Sweden, and United Kingdom, the worst dimension is the environmental one. Instead for Hungary, Spain, Italy, Hungary, Austria, Romania and Slovakia the worst is the social one. Finally, for Ireland, Greece, Croatia, Cyprus, Latvia, Lithuania, Portugal, Slovenia, and Finland the worst dimension is the economic one (see Table 4).

2017	Global	Social	Economic	Environmental
Belgium	1.31	2.23	2.06	1.31
Bulgaria	0.79	0.79	0.95	1.20
Czech Republic	1.26	1.48	2.56	1.26
Denmark	1.58	2.33	2.63	1.58
Germany	1.33	2.07	2.70	1.33
Estonia	1.11	1.28	2.20	1.11
Ireland	1.36	2.21	1.36	2.01
Greece	0.83	0.91	0.83	1.44
Spain	1.15	1.15	1.31	1.93
France	1.78	1.99	2.03	1.78
Croatia	0.88	1.32	0.88	1.42
Italy	1.05	1.05	1.73	1.83
Cyprus	0.96	1.66	0.96	1.49
Latvia	1.07	1.17	1.07	1.95
Lithuania	0.97	1.27	0.97	1.99
Luxembourg	1.05	1.64	2.09	1.05
Hungary	1.13	1.13	1.90	1.50
Malta	1.31	1.36	1.35	1.31
Netherlands	1.28	2.33	2.52	1.28
Austria	1.91	1.91	2.21	2.04
Poland	1.01	1.27	1.65	1.01
Portugal	0.87	1.19	0.87	2.25
Romania	0.55	0.55	0.74	1.23
Slovenia	1.81	2.02	1.81	2.27
Slovakia	1.31	1.31	1.62	1.47
Finland	1.84	2.33	1.84	2.05
Sweden	2.24	2.82	2.35	2.24
United Kingdom	1.32	1.44	2.12	1.32

Table 4: Worst dimension in PCI

4.3 MRP-WSCI AND MRP-PCI: A RESULTS COMPARISON

The MRP-PCI method permits the Decision Maker to assign different compensation indices for each indicator (or each family, subfamily, etc.) of the indicators system. This allows considering different indicators as differently compensable, instead of providing a single compensation index for the entire system as previously done in the MRP-WSCI scheme. For the year 2017, a comparison between the last aggregation of S-W-W and PCI has been done (Figure 15). Both the S-W-W and the global PCI have been run without compensation among the three sustainability dimensions.

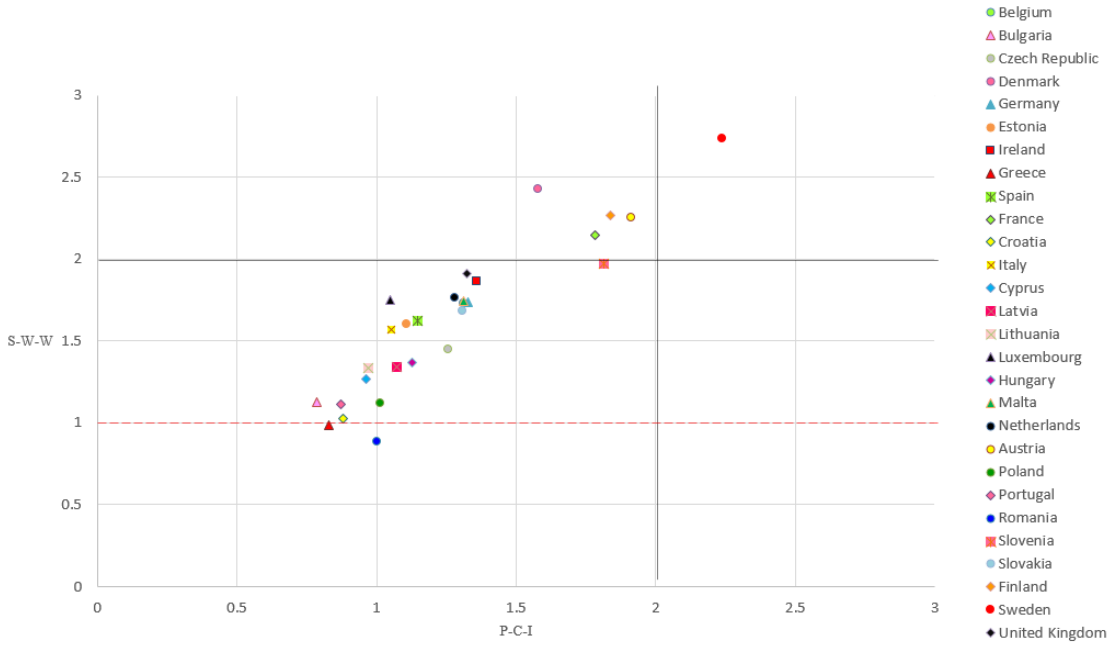

Figure 15: Scatter plot between S-W-W and PCI for the 2017

The PCI shows a drop between -0.1 and 0.84 points in comparison to the S-W-W, for each country. This result is mainly due to the second aggregation step, in which there is a perfect compensation for the S-W-W and a partial one ($\lambda_i = 0.5$) one among the 17 Goals.

5. Conclusions

In this paper, two versions of the Multi Reference Point method were used and compared for the construction of composite indicators: the Multi Reference Point based weak and strong composite indicators (MRP-WSCI) method and the Multi Reference Point based partially compensatory indicator (MRP-PCI) one. The main characteristics of these methodologies are two. Several reference levels can be defined for each indicator, which determine a certain number of performance intervals. Then, with the normalization, all the indicators are conducted on a common scale, which is easily interpretable. The final score is not only a number, but also an informative measure of the problem assessed. The second peculiarity concerns the possibility of building composite indicators for different compensation levels. In the MRP-WSCI compensation it is possible thanks to two different indicators: the Weak Composite Indicator (WCI), which follows a completely compensatory scheme, and the Strong Composite Indicator (SCI), which is completely non-compensatory. In MRP-PCI scheme the Partially Composite Indicator (PCI) is built with the use of a different compensation index for each indicator, component, and size of the indicator system. The rationality and flexibility of the method lies in considering the possibility that a Decision Maker believes that the compensations may not be the same at each level.

The analysis carried out of the objectives of Agenda 2030 for the European Union member states has shown a situation with evident difficulties from the point of view of social sustainability and still major inequalities for economic and environmental sustainability, which stagnates on the levels of sufficiency.

In general, Nordic countries are in a better condition, including those of the Scandinavian peninsula with Sweden at first place, followed by Denmark and Finland; the states of

France and Austria can also be considered good. On the contrary, the States of east Europe, including Romania, Bulgaria, and Greece, with insufficient values, achieve the worst levels. The performance of the remaining states can be considered on the average: looking back to the previous level of aggregation, it highlights many problems at the level of individual Goals and indicators.

The results obtained inevitably lead to wonder if the SDGs can really be achieved and if a development that is sustainable can become reality. This is the greatest challenge that humanity has ever had to face, as it encompasses complex problems all focused on science without having sufficient scientific knowledge spread throughout the world. These are issues of great uncertainty, in chaotic systems. It is a multigenerational problem with which, by tradition, we are not used to confront ourselves.

Agenda 2030 can be a tool for orientating the change that we need: working collectively involving countries and communities towards a common goal. To this end, the plan must adapt to reality and translate it into an ambitious sustainable development strategy, developed by all the territories and political, economic and social actors in a climate of collaboration also with civil society; analyzing resources available and looking at concrete objectives, we must define a clear roadmap for a transformation towards a fairer and more sustainable society, which can improve its social, economic and environmental footprint in the world. In this context, studies such as the present make it possible to establish a benchmark line, measure concretely where we stand with respect to the achievement of global objectives, and the road that is still to be followed.

References

Cabello, J.M., E. Navarro, F. Prieto, B. Rodríguez, and Francisco Ruiz. "Multicriteria development of synthetic indicators of the environmental profile of the Spanish regions." *Ecological indicators* 39 (2014): 10-23.

Cabello, J.M., E. Navarro-Jurado, B. Rodríguez, D. Thiell-Ellul, and Francisco Ruiz. "Dual weak–strong sustainability synthetic indicators using a double reference point scheme: the case of Andalucía. Spain." *Operational Research.* 19, no. 3 (2019): 757-782.

Cabello, J.M., Navarro, E., Thiel, D., Rodríguez, B., Ruiz, F. Assessing environmental sustainability by the double reference point methodology: the case of the provinces of Andalusia (Spain). International Journal of Sustainable Development & World Ecology, 2020.

Cinelli, M., S.R. Coles, and K Kirwan. "Analysis of the potentials of multi criteria decision analysis methods to conduct sustainability assessment." *Ecological Indicators*, no. 46 (2014): 138-148.

El Gibari, S., T. Gómez, and Francisco Ruiz. "Building composite indicators using multicriteria methods: a review." *Journal of Business Economics* 89 (2019): 1-24.

European Commission. 3.3.2010 COM(2010) 2020. Communication from the Commission. EUROPE 2020, a strategy for smart, sustainable and inclusive growth.

Eurostat. "Sustainable development in the European Union. Monitoring report on progress towards the SDGs in an EU context" (2020 edition). ISBN 978-92-76-17443-1 doi:10.2785/555257.

Ruiz, F., J.M. Cabello, and M. Luque. "An application of reference point techniques to the calculation of synthetic sustainability indicators." *Journal of operation research society* 62 (2011): 189-197.

Ruiz, F., T. El Gibari, J.M. Cabello., and T. Gómez. "MRP-WSCI: Multiple Reference Point based Weak and Strong Composite Indicators." *OMEGA: The International Journal of Management Science*, 95 (2020): 102060.

Saisana , M., and S. Tarantola . *State-of-the-art report on current methodologies and practices for composite indicator development.* Ispra- Italy: Joint Research Centre. European Commission, 2002.

Sala, Serenella, Biagio Ciuffo, and Peter Nijkamp. "A systemic framework for sustainability assessment." *Ecological economics* 119 (2015): 314-325.

Ziemba, Pawel. "Towards Strong Sustainability Management—A Generalized PROSA Method." *Sustainability* 11, no. 6 (2019): 1555.

von der Leyen, U. “A Union that strives for more My agenda for Europe”. Political Guidelines for the next European Commission 2019-2024.